ITU-D Study Groups

Study period 2018-2021

Question 1/2
Creating smart cities and society: Employing information and communication technologies for sustainable social and economic development

Annual deliverable 2019-2020

Vertical applications in smart cities

Executive summary

Building on previously delivered annual reports, we present an upper layer of existing and potential vertical applications and services that are based on a common horizontal layer, ensuring integrity and allowing effective interplay among different sectors to facilitate efficient management and innovation for the city or community.

In this document, we stress that, to allow cities to continue to evolve and innovate, we should not see them as the final product but as a platform for sub-platforms. We offer examples of such platforms, including sensors, drones, robots and augmented reality, and present specific applications across different sectors and domains, such as smart utilities, transport, agriculture, energy, street poles, learning and digital government.

Contents

1. Background

Smart cities have traditionally focused on finding solutions to urban problems and modernizing urban services. While excellent results have been achieved in fields such as transport, security and energy, service-focused smart cities are struggling to develop certain urban services. With such an approach, it is very difficult to add new technologies and innovations because services are developed in their final form. Moving forward, smart cities must be platform-based to address this issue.[1]

The crux of this evolution lies not in the vertical optimization of different computer technologies, but in the horizontal penetration of technologies and their integration in all sectors to move from product to service technology.[2]

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2. City platforms

Fundamental to smart city development is clearly defining the concept. With a multitude of interpretations, the smart city concept tends to cause, rather than dispel, confusion as to what a smart city is and how to build one. A particular area of confusion is whether smart cities should be regarded as products or platforms, which have completely different connotations: a product performs a complete and independent function but, once produced, it stops developing, while a platform does not perform a complete function by itself but continues to evolve and innovate.[3]

Another issue is that current governance methods are ineffective against the kind of operational management problems encountered in an urban environment, with massive volumes of data accumulated over the years and large quantities of siloed systems and information. To solve these problems, some cities and companies around the world have been putting into practice the concept of an intelligent operating centre (IOC) or "urban brain."

The formation of a smart city's urban brain needs to be guided by government and driven by the market. It should be aligned with the city's actual development needs and planned and deployed in a coordinated, orderly manner. Furthermore, to ensure safety, stability and efficiency in the construction and operation of new smart cities, the urban brain should have a robust network structure and a sound system of standards, emphasizing safety and controllability. A specialized government-managed agency should be responsible for building and operating the urban brain and data resources. Urban data resource management requires an appropriate legal basis, including the establishment of strategic resource status. Furthermore, it is necessary to establish requirements for data resource aggregation, sharing, exchange and open analysis.[4]

Platforms play a very important role in smart cities by providing the necessary common base for smart city services. Indeed, it is difficult to link services if they are developed and operated on different bases. Smart cities must promote convergence and avoid siloed services. In platform-based smart cities, services can be easily linked and merged, which

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[1] ITU-D SG2 Document 2/343 from the Republic of Korea
[2] ITU-D SG2 Documents 2/283 from China and 2/72(Rev.1) from India
[3] ITU-D SG2 Document 2/343 from the Republic of Korea
[4] ITU-D SG2 Document 2/198 from China

reduces development costs through infrastructure sharing for associated services. To that end, as part of a smart city project, a solution bank[5] should first be created to bring together projects distributed thematically and quantitatively in accordance with an established strategy.

Therefore, new national strategies for smart city development should promote smart cities as platforms. Smart cities should no longer be considered a finished product like their urban components, such as buildings, cars and roads, but as a platform that continues to evolve through the linking of resources, data and different services.[6]

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Table 1: Platform-based vs service-focused smart cities[7]

Platform-based smart cities	Service-focused smart cities
– Sharing of service infrastructure – Convergence of related services – Lower development costs – Innovation by all players – Bottom-up development	– Silos of service infrastructure – Separation of related services – Higher development costs – Innovation by big players – Top-down development

a) Sensor network

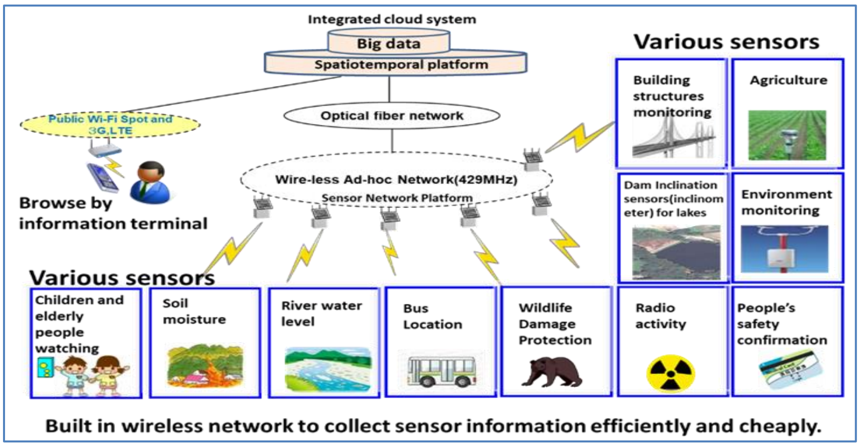
A sensor network can be easily deployed around a gigabit Ethernet fibre network and wireless local area network, with an ad-hoc configuration and interconnection with upper-layer service providers. Distributed wireless repeater stations can be powered by solar panels and operate autonomously using low-cost IoT sensors that are efficiently interconnected. The IoT sensor network covers the region. Unique automatically collected data may be analysed in combination with other data, in consideration of time and location, for valuable new information of importance for regional economic development.[8]

Many smart city initiatives will start small but grow fast and scale up significantly. Consequently, now is the time to anticipate massive uptake in sensor devices and applications, as well as equivalent growth in data and network traffic, which can only be achieved through ICT infrastructure that is scalable by design.[9]

Sensors may include: monitoring systems for children and elderly people, soil moisture sensors, river water-level sensors, sensors to protect against damage to wildlife, radio activity sensors, sensors to confirm safety of people, building-structure monitoring sensors, agricultural sensors, dam inclination sensors (inclinometer) for lakes and environmental monitoring sensors.

[5] ITU-D SG2 Document 2/266 from the Russian Federation
[6] ITU-D SG2 Document 2/198 from China
[7] ITU-D SG2 Document 2/343 from the Republic of Korea
[8] ITU-D SG2 Document SG2RGQ/28 from Japan
[9] ITU-D SG2 Document SG2RGQ/TD/2 from the Co-Rapporteurs for Question 1/2

Figure 1: Environmental information data-collection platform and IoT sensor network

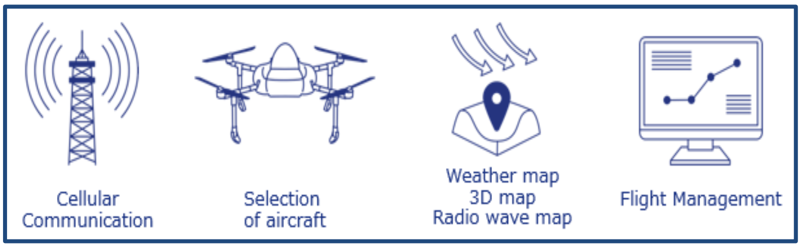


b) Drone platform

A smart drone platform is a solution worth considering to facilitate the use of drones in smart cities. Useful features are integrated in a single platform, which allows remote drone monitoring and control from a dashboard on the platform. Drones' various capabilities, such as live video and weather, 3D and radio wave mapping, are supported by mobile networks, the cloud and artificial intelligence for data analysis.

Drones can be used for many services, including inspection of roads, railways, power grids, telecommunication towers, disaster relief, public safety by detecting suspicious behaviour at large-scale events (e.g. stadiums) and detection of disease in vegetation to prevent spread of damage at an early stage.[10]

Figure 2: Smart drone platform



Box 1: Use of drones to combat COVID-19

> In the war against COVID-19, drones are playing a key role by helping authorities and people to prevent further spread of the disease. In some areas where individuals are, knowingly or unknowingly, failing to comply with the measures in place, law enforcement authorities, such as the local police or municipal authorities, use drones to monitor people's movement and disperse social gatherings that could pose a risk to society.
>
> In addition to street surveillance, authorities are also using drones to broadcast messages and information about lockdown measures, especially in rural areas lacking open communication channels for health information. Drones equipped with loudspeakers are used to make public announcements to ensure that people stay indoors and respect social distancing and wear masks when stepping out. In addition, crop-spraying drones are being filled with disinfectant and used to disinfect public spaces and potentially affected areas.

[10] ITU-D SG2 Documents SG2RGQ/176(Rev.1) from KDDI (Japan) and SG2RGQ/173 from Shinshu University (Japan)

This technology is particularly useful where outside physical contact and exposure of medical staff should be kept to a minimum. Some drones are used to deliver groceries in red zones, while others equipped with infrared cameras measure the temperature of people who are confined to their houses.

Drones must be used, however, in strict compliance with each country's specific regulations. The use of drones for surveillance purposes sparks heated debate about privacy and individuals' rights in mainstream media and on social media platforms.

c) Augmented reality platform

Augmented reality reinforces users' cognitive ability by adding data information on top of real-world information. Car navigation services are already helping drivers to find their intended destination. In order to optimize the use of augmented reality, it is necessary to accurately express the physical world in cyberspace and to upload various data on top of it. In the future, smart cities will be able to solve various challenges of urban living by introducing augmented reality technology across different fields. For example, it could be used by foreign visitors to overcome a potential language barrier.

d) Robot platform

Perhaps the biggest change in future smart cities would be the widespread use of robotics. At present, robot technology has not developed sufficiently to be used in current urban environments, but it is expected that this problem will be soon overcome. In particular, smart cities can help to promote the use of robotics by accommodating the incompleteness of robot technology. The building of an urban infrastructure to enhance the functionality and stability of robots will allow robot technology to be used in smart cities in the near future. Urban infrastructure should be designed not only for humans but also to facilitate use of robotics and reserve a separate urban platform for robots.[11]

3. Smart services and applications

3.1. Utilities

Smart housing and utilities are included in smart city projects with a view to the automation of housing and utility facilities in order to ensure timely utility meter readings and transparency for utilities, perform quality control of equipment and prevent emergencies, etc.[12]

Generally, smart housing and utilities can be divided into three levels: installation of meters in apartments and houses, reading of meters and processing and analysis of data.

The following are involved in the implementation of smart housing and utilities:

- introduction of smart utility resource accounting systems;
- introduction of digital modelling for infrastructure management;
- introduction of automated systems for monitoring a building's condition, including noise level, temperature, etc.;
- introduction of automated performance review for actions on consumer requests and incident response.

The mass production of smart gas, water and electricity metering devices will allow for the management of electricity consumption from mobile applications. Smart devices will be able to receive and transmit information over the Internet. These transmissions will be protected cryptographically from unauthorized access and any attempts to change meter data. All data will be transmitted to the resource-supplying organizations and uploaded to

[11] ITU-D SG2 Document 2/343 from the Republic of Korea
[12] ITU-D SG2 Document 2/TD/10 from the Russian Federation

the end user's mobile application, allowing the customer to control all metering and pay for utilities online.

A wireless system for remote smart housing and utility meter readings will allow for:

- increased revenue collectability from consumers;
- automated readings from water, electricity, heating and gas meters;
- end-to-end control of resource consumption for individual apartments and entire buildings;
- lower costs and less time associated with data collection and processing.

A reliable and complete energy metering system serves as the basis for reduced consumption and increased energy efficiency and solves the problem of non-payment for energy. It will also facilitate the operation of smart grid-like distribution networks, as metering devices are crucial control elements in such networks.

Saving energy in residential or office buildings is important financially and environmentally as such buildings are voracious energy consumers and produce large amounts of CO_2. New construction standards are required for intelligent buildings, whose control systems can adapt to any given situation to avoid unnecessary energy consumption through the use of photovoltaic sensors, solar water heaters, wind turbines, geothermal heat pumps, good insulation, air circulation and surplus energy production in the case of energy-positive buildings.

Smart buildings promise convenience, well-being, information, the safety and security of property and people and ease of operation and maintenance. Building-structure sensors can monitor the deterioration of public buildings and structures, in particular bridges and tunnels suffering the effects of aging. These sensors facilitate decision-making to prevent any further deterioration after the detection of, for example, an anomalous structural vibration. A dam tilt sensor system, meanwhile, can detect the collapse of a dam by filling the tilt sensor inside and outside the dam structure.[13]

Intelligent fire prevention and other such applications offer new methods and opportunities for risk prevention and control in an urban residential setting and should involve the following: intelligent equipment, intelligent warning and alarm systems and big data application.

Intelligent fire prevention systems facilitate intelligent interaction among three groups of users: community residents, property management and the fire brigade. Their application of such systems for risk prevention and control in an urban residential setting requires: monitoring and early warning through various sensors, monitoring of water source for fire control, fire prevention facility inspection, combustible gas alarm control, automatic fire alarm, fire access/key location monitoring and a smart energy system.[14]

3.2. Transport

The global population is constantly growing and increasingly concentrated in large urban centres. Urbanization leads to an increase in the number of vehicles on the roads, contributing to a rise in congestion and the number of traffic accidents. Each year traffic accidents claim the lives of more than 1.25 million people, while congestion not only leads to financial and time losses but also contributes to air pollution and global climate change and delays the arrival of emergency responders to the scene of an accident, thereby reducing victims' chances of survival. A big challenge facing growing cities is how to ensure the safe, secure and efficient transport of people and goods.

In this regard, the importance of developing an intelligent transport system (ITS) is not

[13] ITU-D SG2 Document SG2RGQ/28 from Japan

[14] ITU-D SG2 Document 2/283 from China International Telecommunication Construction Corporation (China)

only underlined by the ever rising number of cars on city roads and resulting congestion levels, but also, and mainly, by the need to guarantee the safety and comfort of all road network users, achievable with the introduction of innovative technologies and new management decisions.

ITSs comprise infrastructure, modes of transport, system users and road traffic regulations and can involve different models, technologies and systems. They usually include systems for traffic-light network management, freight regulation, vehicle registration number recognition and even bridge-building and meteorological support systems. ITSs can also involve the use of various models which take account of the huge quantities of road traffic data accumulated.

ITSs generate information on the load and condition of the road traffic network and provide hardware and software solutions to ensure that data are gathered, processed, stored, kept up to date and made available to stakeholders.[15] Thus, the use of open data is key for developing safe, trusted public transport services. When made accessible, real-time data help users to make better choices for their journey and establish priorities (e.g. safety, travel time, cost, etc.).

Bus rapid transit (BRT) networks figure prominently in countries' smart transport strategies. With the help of advanced ICTs, BRT networks enhance the efficiency and effectiveness of bus services by providing seamless, fast, reliable, safe and convenient public transport. Compared with metro and rail networks, BRTs' shorter establishment lead-time means that they can quickly transform transport routes and deliver positive results to alleviate congestion and pollution, providing an earlier return on investment.[16]

Following on from the Final Report on Question 1/2 for the study period 2014-2017,[17] it is also important to optimize traffic control for efficient transport by introducing IoT sensors and AI technology in the surveillance camera systems of existing ITSs. The first step in this regard is traffic counting as the traffic situation can be visualized by measuring traffic flow from information obtained by IoT sensors and surveillance cameras. Image analysis is key for this purpose. It is important to understand how many people are using the transport network, rather than just how many vehicles, as AI systems can count the number of passengers in each vehicle. The process can be broken down into four steps: traffic flow data are accumulated as big data and analysed by AI; the cause of traffic congestion is analysed; traffic demands and congestion are predicted; and traffic flow is dispersed based on predicted data and traffic control is optimized. The predicted data are also used for long-term urban planning. It is not possible to plan and accurately estimate the levels of public transport required to alleviate traffic congestion, if only the number of vehicles is counted. A similar ICT system can also be used to count motorcycle and bicycle users in town and even pedestrians in shopping areas, stations, stadiums and tourist spots and to allow for visualization of mobility, cause analysis and prediction of congestion and optimization of mobility to ease congestion.[18]

3.3. Agriculture

ICTs have great potential to accelerate countries' achievement of national agricultural goals and SDG targets. Strategic deployment of these solutions would significantly accelerate the capability to harness their potential.

As situations vary according to country and region, it is critical to develop e-agriculture strategies according to the given ICT and agricultural context. Strategies should include an action plan, contribute to bringing key stakeholders together and build synergy in

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[15] ITU-D SG2 Document 2/266 from the Russian Federation

[16] ITU-D SG2 Document SG2RGQ/186 from the NEC Corporation (Japan)

[17] The Final Report on Question 1/2 for the ITU-D study period 2014-2017 can be found at: https://www.itu.int/pub/D-STG-SG02.01.1-2017.

[18] ITU-D SG2 Document SG2RGQ/73 from the NEC Corporation (Japan)

solution deployment. When implementing an ICT solution in agriculture, it is essential to choose the most appropriate solution from among the various options available.

For developing countries, where agriculture is a major driver of the national economy, provenance-supported value chains are seen to be vital to future economic and social sustainability. It is therefore necessary to analyse what groundwork needs to be laid at global, regional and national levels to introduce appropriate technologies aimed at improving food production, quality and livelihoods in a sustainable manner, including in terms of collaboration, infrastructure, capacity and digital literacy.[19]

Faced with the urgent need to revolutionize traditional agriculture, FAO will develop a concept for the establishment of an international digital council for food and agriculture, in consultation with stakeholders including the AfDB, CTA, IFAD, ITU, OECD, OIE, World Bank, WFP and WTO. This digital council will provide structured and strategic policy recommendations on the digitalization of food and agriculture, organize efforts to share best practices for smart rural communities and promote interaction among countries and other stakeholders towards achieving the SDGs.[20]

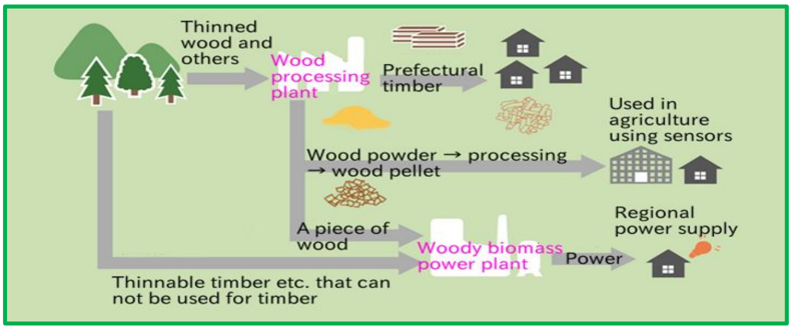
It used to be difficult to predict serious frost damage to crops; with an appropriate IoT sensor network, however, frost warnings can be issued based on site temperature and moisture levels to protect crops from any damage.[21]

ICTs and AI can be used for hydroponic farming[22] in greenhouses as a cost-effective solution to increase productivity and reduce workload for farmers. This method of e-agriculture helps to vitalize the regional economy and is of particular interest for arid and desert areas. The system involves the deployment of various IoT sensors and the sharing of obtained data among the sensors, sequencers and cloud computing system via communication networks, which allows greenhouse conditions to be monitored remotely from smartphones. By digitizing expert know-how, the nutrient solution irrigation settings can be properly controlled according to the different growing stages of fruits and vegetables.[23]

3.4. Energy

Natural and renewable energies are becoming increasingly popular, in particular biomass energy. Biomass power plants contribute to the establishment of a regional industry chain from forestry and lumbering, including the production of wood chips, to sustain environments surrounded by forestry and mountain ranges. In addition, the supply of biomass energy to the electricity network can contribute to ensuring the resilience of ICT infrastructure and to reducing greenhouse gas emissions in line with the SDGs.[24]

Figure 3: Regional power grid using biomass generation to supply ICT networks

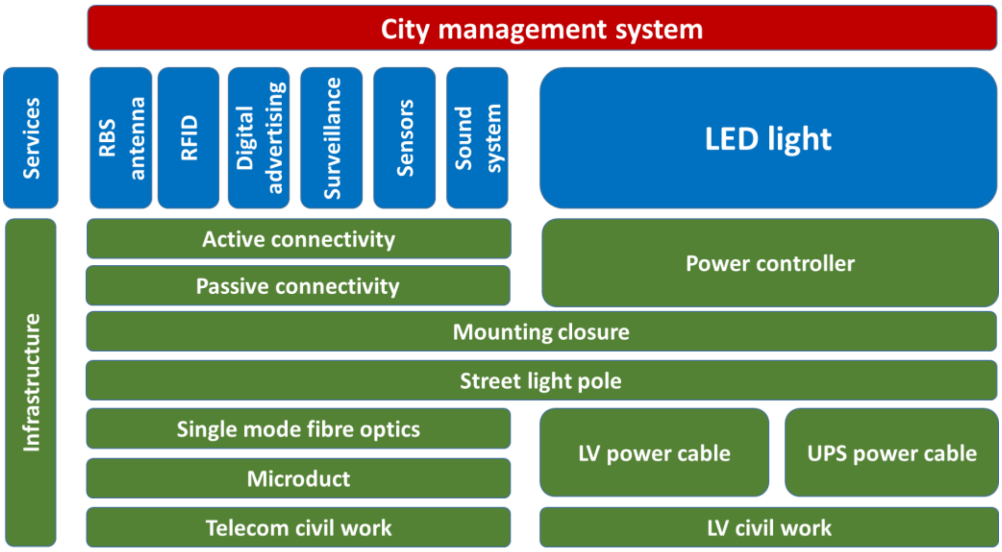


[19] ITU-D SG2 Document 2/200 from the BDT focal point for Question 1/2
[20] ITU-D SG2 Document 2/330 from the BDT focal point for Question 1/2
[21] ITU-D SG2 Document SG2RGQ/28 from Japan
[22] Hydroponic farming is the above-ground cultivation of plants using a neutral and inert substrate.
[23] ITU-D SG2 Document SG2RGQ/29 from Daiwa Computer Co. (Japan)
[24] ITU-D SG2 Document SG2RGQ/28 from Japan

3.5. Street poles

Egypt has reported a smart street pole design that should provide consumption savings and enable the provision of additional services related to security, traffic control and transport management, which benefit communities and businesses and involve several stakeholders, including ministries across multiple domains, such as housing, the interior, electricity, ICTs and the environment, and municipality services for advertising, smart parking, etc.[25]

Figure 4: Smart street pole components



3.6. Learning

The issue of direct involvement in the region through capacity building programmes in ICT skills can be addressed upstream by generating engagement in the region itself and offering students of elementary schools, local colleges and high schools the opportunity to solve real problems facing their communities with ICTs and the support of relevant regional stakeholders.

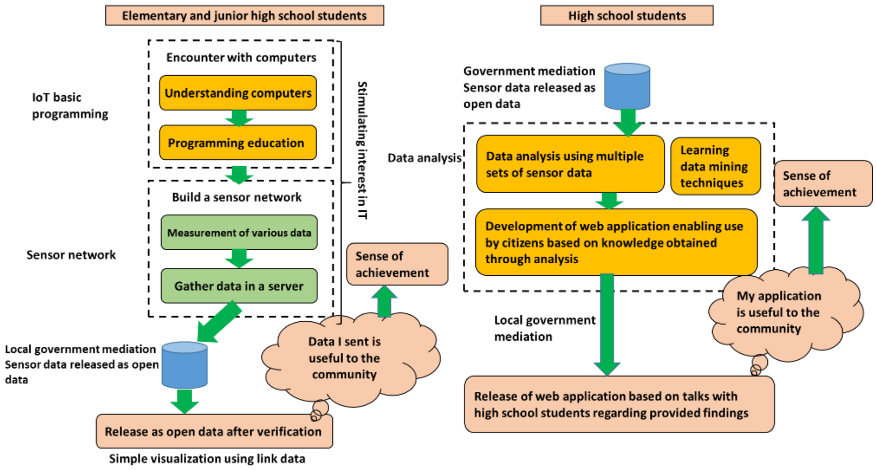
It is also an opportunity for many countries experiencing a shortage in human resources with technical ICT skills to develop an educational strategy to retain the few specialists they do develop, who tend to leave their regions for big cities.

Curriculum and instructional aid requirements

– allow students to learn how to solve local problems using computer technology;
– stimulate interest in ICTs and develop capacity to solve social problems;
– transmit advanced technologies and knowledge in fields such as IoT and data science;
– allow for easy programming;
– ensure low-cost availability and ease of use, even at home;
– allow easy connection of external devices.

[25] ITU-D SG2 Document SG2RGQ/195 from Egypt

Figure 5: Example of curriculum currently under development



A local government is enabling citizens to use data gathered by elementary and junior high school students for easy visualization and released as open data via LinkData modules. Consequently, the students recognize that the system they have built is useful to the community and they can learn while gaining a sense of achievement.[26]

To cope with the spread of COVID-19, most governments around the world have temporarily closed educational facilities. This has thrown into sharp relief new challenges requiring collective global action to mitigate the immediate impact of school closings, especially for vulnerable and disadvantaged communities, and to facilitate continuity of education for all through distance learning.

The sudden generalization of distance learning has given rise to many questions, such as the management of teaching materials that are not accredited by credible institutions, compliance with rules relating to the collection, management and use of data, in particular the personal data of children and young people.

Even though many virtual e-learning platforms have kept the relationship between teachers and students alive and helped them to stay motivated, this crisis has revealed the need to improve network connectivity in landlocked regions to fight against inequalities, including in developed countries. Thus, there is no doubt that this crisis will change the way that we think about the future of education in all its aspects.

3.7. Digital government

Given the potential of ICTs, the question facing governments is how to adapt to facilitate adoption of ICTs and ensure that their potential makes a real difference to people’s lives and to digital transformation. They must also ask how the potential of big data analytics, AI and IoT can be harnessed to drive greater efficiency and sustainability in smart cities and societies worldwide.[27]

Intelligent governance refers to the use of ICTs, such as big data, cloud computing, IoT, etc., in city management, the environment, public safety and emergency accident processing areas for accurate analysis, monitoring and feedback. ICTs not only offer tools for managing the public affairs of state and society effectively but also bring about change in the mode of social governance from government control to collaborative governance.[28]

Digital government is not just a matter of simplifying administrative procedures by operating without paper. Efforts should be made to digitize procedures in all areas and at

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[26] ITU-D SG2 Document SG2RGQ/161 from Shinshu University (Japan)

[27] ITU-D SG2 Document SG2RGQ/TD/2 from the Co-Rapporteurs for Question 1/2

[28] ITU-D SG2 Annual deliverable on Question 1/2 for the period 2018-2019, “A holistic approach to creating smart societies”, 2019, https://www.itu.int/oth/D0717000002

all levels of public administration and in all private sectors using digital technologies. Each country is currently considering a digital government strategy. As administrative procedures are digitized, a method of personal authentication, such as signatures, should also be considered. Mobile devices will become an essential tool of digital government. Digitalization through ICTs generates value of efficiency in terms of the time and cost associated with the administrative procedures of all governments and private sectors.

Shifting to digital government offers more value in terms of security and equality. Some governments favour the introduction of a system which uses biometric data to identify and authenticate registered persons. The purpose of this personal authentication system is so that governments can provide public and financial services on an equal basis to all citizens and prevent illegal access. Identity theft can also be prevented with the use of fingerprints, physical images and iris images.[29]

Empowering citizens, especially vulnerable groups and women, through ICTs is necessary to ensure equitable access to ICT infrastructure, facilitate access to public services and ensure the digital inclusion of all parts of the country. An inequitably distributed information revolution risks increasing the digital divide and exacerbating poverty in rural areas. Excluded regions/areas must be covered by ICTs/applications in order to minimize the gap between developed and underdeveloped regions.[30]

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[29] ITU-D SG2 Document SG2RGQ/73 from the NEC Corporation (Japan)
[30] ITU-D SG2 Document 2/72(Rev.1) from India