

THE ROLE OF 5G/6G CELLULAR NETWORK TECHNOLOGIES IN ACHIEVING THE GOALS OF SUSTAINABLE DEVELOPMENT

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ABSTRACT: The main global goals of sustainable development of humanity by 2030 have been identified. It is obvious that information technologies can play one of the key roles in their successful achievement. In this context, within the framework of this work, the existing potential of cellular networks for the impact on the successful achievement of sustainable development goals was analyzed. The main domains where a significant contribution can be made through the use of mobile technologies were analyzed. But there are also risks that can have a negative impact on the achievement of global goals of sustainable development. The result of this study is also reflected in this article. And finally, the potential of the introduction of modern cellular networks within countries with developing economies was demonstrated.

KEYWORDS: *Sustainable Development, Cellular Network, 5G, 6G, New Technologies, SDG*

INTRODUCTION

The United Nation's Sustainable Development Goals (SDGs) are a universal call to achieve a sustainable future and promote equality, human rights, and justice for all by 2030 [1 Adopted by UN Member States in 2015, the 2030 Agenda for Sustainable Development provides a shared strategy for peace and prosperity for all people and our planet, now and into the future. The SDGs are a collection of 17 interlinked goals designed to guide reflection and action on the most pressing challenges and opportunities facing humanity and the natural world, including inequalities (SDG 10), climate change (SDG 13), peace and justice (SDG 16), and global cooperation to meet global targets (SDG 17). These goals and their targets acknowledge that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, social inequalities, and economic disparities—all while tackling climate change and working to preserve our natural surroundings.

The SDGs establish a blueprint for global citizens to work together to build a better world, for it is only by working collectively—across borders and disciplines and with community partners—that these goals might be achieved. Through research, teaching and learning, community engagement, and global collaborations, IU Indianapolis is playing a leading role in tackling the SDGs and achieving the 2030 Agenda.



Fig. 1. Global goals of sustainable development [1]

MOBILE NETWORKS DEVELOPMENT

In order to achieve the global goals of sustainable development, it is necessary to use all available high-tech tools, which to one degree or another will bring the world community closer to the realization of the most ambitious ideas for global well-being. The potential contribution of the ICT industry to achieving the goals of sustainable development should be noted separately.

According to a research paper by Ericsson [3] on the potential of ICT to reduce greenhouse gas emissions, the ICT sector has the potential to reduce total industrial emissions worldwide by up to 15%, although it accounts for only 1.4% of the global carbon footprint. The study highlights the importance of 5G as a key building block for a future Net Zero [4].

One of the key drivers of the development of the ICT industry is cellular networks. They are developing at a very rapid pace and this is evidenced by a number of studies and the results of the analysis of the subscriber base (Fig. 2).

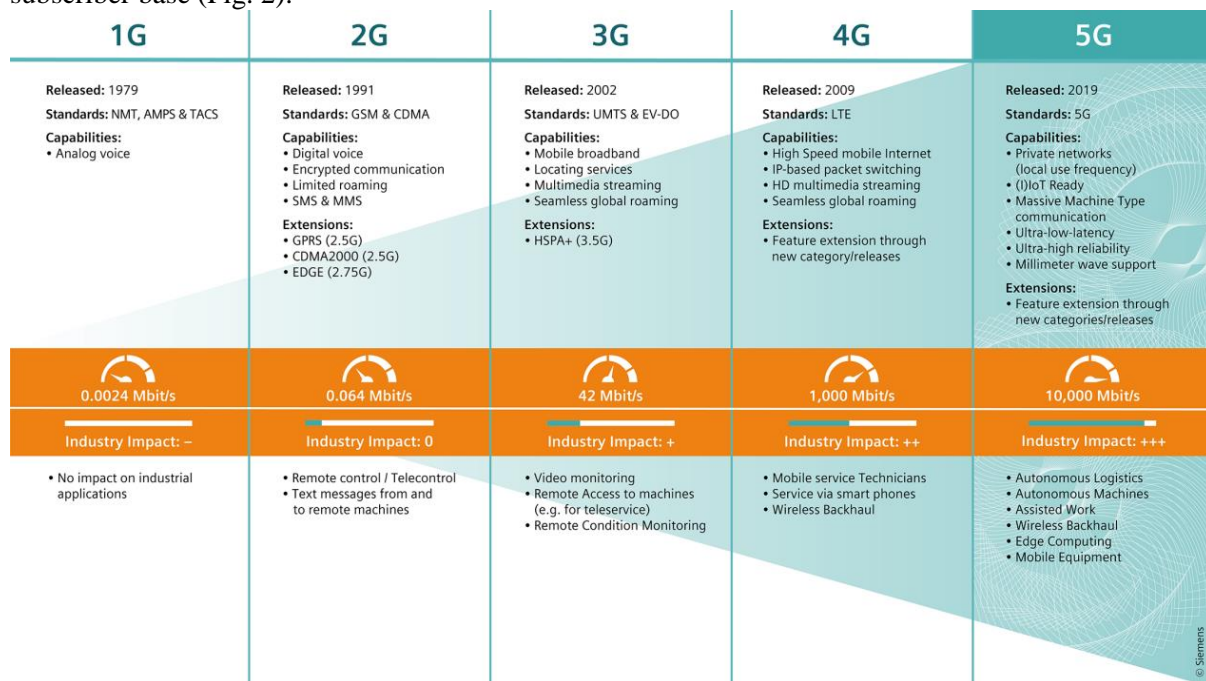


Fig. 2. Cellular networks evolution [3]

POTENTIAL OF MOBILE NETWORKING IN ACHIEVING THE SDGs AND POTENTIAL RISKS

Thus, the latest cellular network technologies can also make a significant contribution to achieving sustainable development goals. The main areas in which mobile technologies can make a contribution are discussed below.

Ultra-Low Latency. Both 5G and 6G networks are designed to offer incredibly low latency, which is crucial for real-time applications. This feature supports innovations in healthcare (remote surgeries), transportation (autonomous vehicles), and smart grids for efficient energy management.

Massive Connectivity. 5G enables the connection of billions of IoT devices globally, paving the way for smart cities, smart agriculture, and smart industries, all of which contribute to more sustainable practices by optimizing resources and reducing waste.

Energy Efficiency. 5G and future 6G networks are designed to reduce energy consumption through more efficient data transmission and smarter infrastructure, contributing to a reduction in the global carbon footprint.

Enhanced Network Reliability and Speed. These networks ensure reliable, high-speed connectivity, which can drive digital inclusion by enabling access to education, telemedicine, and other essential services, even in remote areas, supporting goals like quality education and health.

Integration with Advanced Technologies. 5G/6G will integrate with AI, edge computing, and blockchain to enable innovations like predictive maintenance in industries, smart environmental monitoring systems, and secure data sharing for sustainable development initiatives.

The latest generation of mobile radio communication networks today are 5G networks. However, the benefits of 5G are not limited to the ICT sector. The technology represents an open innovation platform that serves a multitude of sustainable uses – from smart farms to smart factories – by improving automation, increasing productivity, increasing energy efficiency, conserving resources and increasing resilience to climate change. 5G can also contribute to the decarbonisation of the world's largest carbon-emitting sectors, namely energy, manufacturing and transport, by improving data sharing, optimizing systems and increasing operational efficiency, thereby accelerating global efforts to reduce carbon emissions.

In general, projecting the role of 5G on the process of achieving the goals of sustainable development, we can draw a conclusion about the opportunities that this technology opens up in various sectors of the economy (Fig. 3).

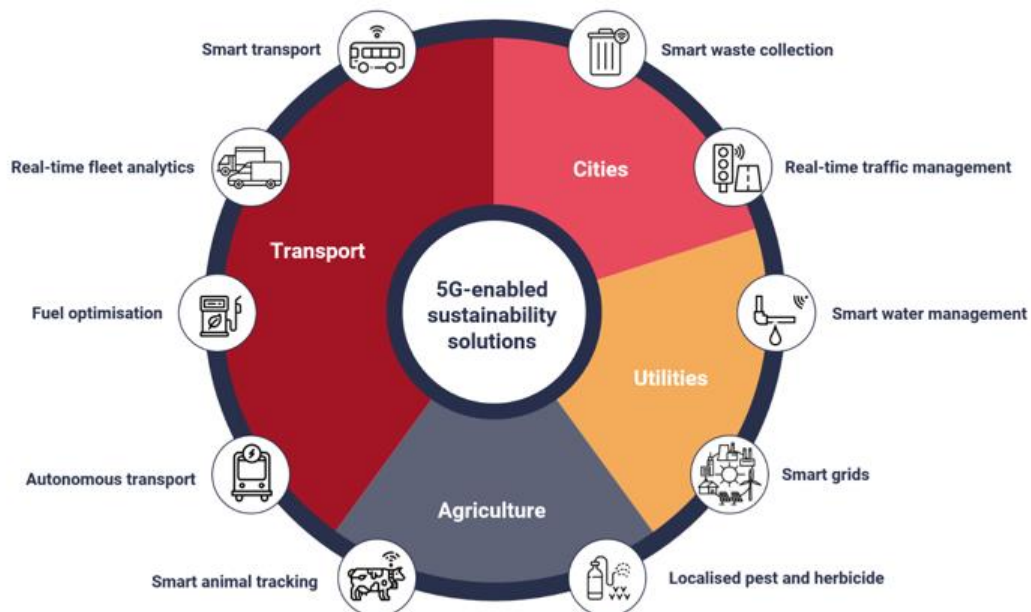


Fig. 3. Contribution of 5G to achieving the goals of sustainable development [6]

5G networks have more advanced features than networks of previous generations. They are equipped to handle large amounts of data with minimal latency (ultra-low latency) and support an extremely high density of connected devices (machine-type mass communication). This improved connectivity has unlocked a range of new 5G-enabled sustainability services that individuals, companies and governments can implement to reduce their carbon footprint and achieve other sustainability goals. But improved connectivity will also mean that more devices will be connected to the network, increasing the energy consumption of the network. Telecommunications companies and service users need to take immediate action to limit this environmental impact.

The environmental impact of 5G thus encompasses more energy-efficient network technology that helps telcos minimize their environmental impact, as well as enabling technology that telcos can use to help businesses, governments and consumers reduce their own environmental impact.

Along with this, cellular communication networks continue to develop at a rapid pace. Currently, development is underway to coordinate Release 19, which will have a significant number of new advanced technologies that will open the possibility of achieving the goals of sustainable development, including (Fig. 4).

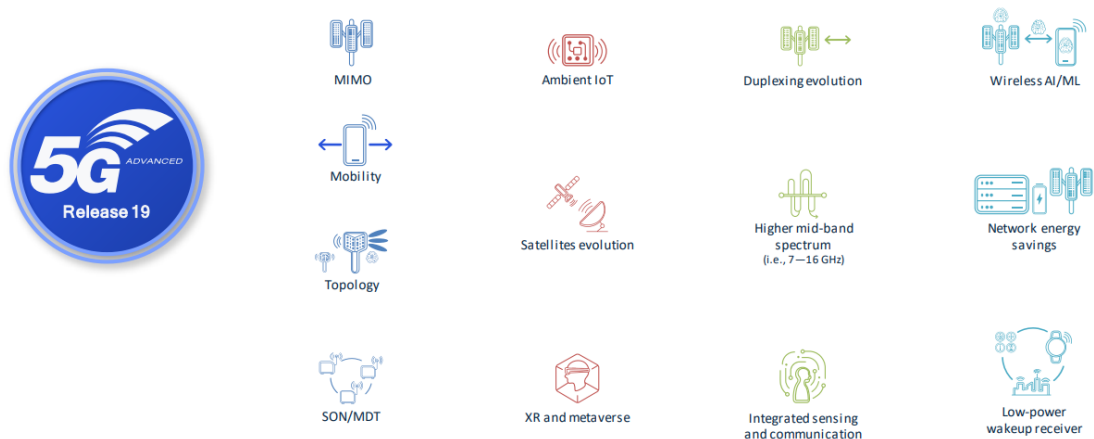


Fig. 4. Technological innovations in 5G Release 19

But there are already many examples of using 5G to achieve the UN's sustainable development goals. Below are some of them.

Nokia and Elisa's 5G Liquid Cooling Station uses wasted energy from Elisa's networks to heat buildings and water. This allowed Elisa to reduce the energy consumption of its 5G networks by 30% and reduce overall CO₂ emissions by 80% [7].

Some operators use intelligent network software that allows base stations to turn off power depending on quiet times of day (such as at night) or periods of general low traffic. Such innovations are key to the telecommunications industry, which now produces c. 0.8% of all global emissions. We explored these topics in more detail in our report, *Why Power Management is Critical to 5G Success*.

e& is decarbonizing its network with sustainable 5G solutions. They plan to achieve this by partnering with Ericsson to implement changes such as RAN's intelligent energy-saving software features, as well as other initiatives such as its global product return program to increase recycling and responsible disposal of e-waste across e&'s network [8].

The Telia and Ericsson Autonomous Electric Bus solution relies on 5G network capabilities for live video positioning and prioritization [9]. During the trials, 5G control towers were used to remotely control buses and transmit real-time video to track journeys and ensure passenger safety. Automated vehicles enabled by 5G IoT technologies are more fuel-efficient than manual alternatives, reduce greenhouse gas emissions from public transport, make public transport more accessible and lower operating costs.

Proximus [10] solutions for weed and pest control use drones to capture images of agricultural plots and artificial intelligence to identify the nature of weeds or diseases in crops. Proximus provides 5G connectivity that allows data to be sent from the drone to the analytics platform. The analytics platform then creates a task map for a robot equipped with a torch (for weeds) or a pesticide sprayer (for pests or diseases). Instead of treating the entire field for pests or diseases, this allows farmers to treat only the affected areas. By 2030, European farmers will have to reduce their use of pesticides by 50%. In this test case, Proximus found that pesticide use could be reduced by 80%.

The City of Rotterdam's smart waste management system [] uses IoT sensors in bins and other waste disposal areas to monitor fill percentages. This data is transmitted via the KPN 5G LoRa network to a centralized control system that determines dynamic routes for waste collection vehicles. 165 dynamic waste collection routes replaced 203 static routes, resulting in a 20% reduction in vehicle kilometers driven for waste collection. In turn, this resulted in a 20% reduction in CO₂ emissions, as well as a 25% reduction in labor and equipment costs.

Thus, in summary, it can be argued that 5G and future 6G cellular network technologies have significant potential to promote sustainable development. Their high throughput, low latency and high scalability make them key tools for various initiatives to improve the quality of life and preserve the environment. With the help of 5G/6G technologies, it is possible to ensure efficient use of resources, develop the "Internet of Things" and "smart" systems, increase the availability of education and health services,

promote the development of remote work and mobility, and also increase the competitiveness of the economy. Therefore, the role of 5G/6G cellular network technologies in sustainable development cannot be overestimated. Their implementation and use open up new opportunities for creating more efficient, intelligent and ecologically clean communities.

But also with the introduction of new mobile network technologies, a number of risks also arise, presented in Table 1.

Table.1. Potential risks while introducing 5G/6G technologies for achieving the SDG

High Energy Consumption and Environmental Impact	While 5G/6G networks promise energy efficiency, the infrastructure deployment (like base stations and data centers) can consume substantial power. Without renewable energy sources, this may increase carbon emissions, counteracting the environmental benefits.
Digital Divide	The rapid rollout of 5G/6G may widen the gap between regions with access to advanced networks and those without, particularly in rural or underdeveloped areas. If not addressed, this digital divide can limit the global equity and inclusiveness intended by the SDGs.
Cybersecurity Risks	As 5G/6G expands the Internet of Things (IoT) and connects billions of devices, it also increases the potential for cyber-attacks. Ensuring robust cybersecurity measures is essential to prevent data breaches, identity theft, and other forms of cybercrime, which could undermine trust in digital solutions.
Cost and Infrastructure Requirements	The infrastructure needed to support 5G/6G networks, such as base stations and fiber-optic connections, is capital-intensive. For many countries, especially developing ones, the costs of implementation might be prohibitive, slowing down adoption and limiting the impact on sustainable development goals.
Privacy Concerns	With billions of connected devices gathering personal and industrial data, privacy concerns are heightened. There is a need for strong data governance policies to ensure that sensitive information is protected, and individuals' privacy rights are upheld.

But despite the risks presented above, mobile technologies can still have a significant impact on the process of achieving the SDGs (Fig. 5).

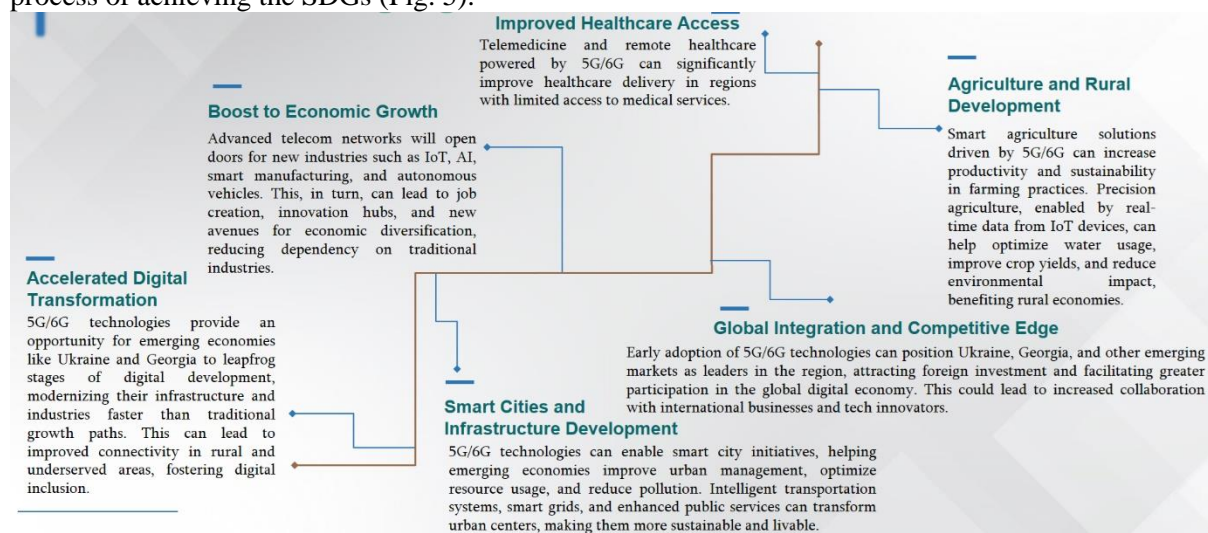


Fig. 5. The potential of using cellular networks to achieve sustainable development goals

CONCLUSIONS

Considering this figure, the next conclusion can be drawn. In any case, there are a lot of opportunities for Ukraine, Georgia, and other emerging economies while developing the novel mobile network technologies.

5G/6G technologies offer immense opportunities to drive innovation, economic growth, and sustainability across industries and sectors. Their ability to improve connectivity, support smart cities, enhance healthcare, and enable efficient resource use aligns directly with the UN's Sustainable Development Goals (SDGs).

By connecting people, industries, and technologies, 5G/6G networks will serve as key enablers for addressing critical challenges like climate action, education inequality, and urbanization.

While 5G/6G bring significant benefits, challenges such as digital inequality, high energy consumption, and cybersecurity risks need to be addressed through policy, investment, and innovation.

Thus, to maximize the potential of 5G/6G, collaboration between governments, industries, and communities is essential to ensure that the technology is accessible, secure, and environmentally friendly.

ACKNOWLEDGMENT

This work was supported by Shota Rustaveli National Science Foundation of Georgia (SRNSFG) - CG-24-220

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