NEW TECHNOLOGIES IN AGRICULTURE AND SMART VILLAGES

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Abstract

By new technologies, we mean, above all, precision agriculture and digitization. Precision agriculture and digitization of agriculture lead to the realization of the concept of smart villages. If the digitization of the villages succeeds, through Internet possibilities such as remote work, e-learning, better health care or shopping via e-commerce, rural areas can gain the attraction that big cities have, and which they have partially lost, which would stop depopulation and deagrarianization of villages. Multiple services can be implemented in a smart village in order to improve the quality of life, living standards of the local population, implement and improve the model of sustainable development and establish effective resource management. The sensors are related to the collection of various data related to weather conditions, soil moisture, soil electrical conductivity, soil pH and crop monitoring. Technical solutions will depend on factors such as the size of the village, available resources and the desired level of data analysis and storage capabilities.

Key words: *new technologies in agriculture, smart villages, precision agriculture, digitization, technical solutions, sensors.*

Introduction

Achieving the Millennium Development Goals, the developmental agenda for the period post-2015, and the United Nations goals for access to energy until 2030 require concerted efforts focused on rural areas, where approximately 70 percent of the world's poor reside [2], [10]. Relying on a more commercialized and highly praised concept and blueprint of smart cities, the concept of smart villages offers a bold, flexible, and scalable system design.

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This design can be implemented in rural areas, providing multiple options for the local community to advance and thrive. The progress and prosperity resulting from this model approach are not limited solely to the rural areas, but also extend to encompass benefits for municipal, state, regional, and international aspects of development.

According to Anthony M. Townsend, an American researcher and author of the book “Smart Cities,” he envisions smart cities as projects where computer and information technology intersect with various fields, such as construction, traffic management, ecology and sustainable development, urban infrastructure, household appliances, architecture, and even wearable technology for individuals (e.g., measuring blood pressure, oxygen levels, sugar levels, etc.) [5].

Until today, inefficient and health hazardous kitchen stoves continue to be the only accessible and highly affordable cooking method for 2.7 billion people living in rural areas [2]. This issue stems from an even more daunting reality: 1.3 billion people worldwide lack access to electricity, which is considered a fundamental aspect of civilization. Availability of electricity and energy is a critical prerequisite for these individuals to lead significantly improved and dignified lives. Former Secretary-General of the United Nations Ban Ki-moon stated in this regard, “Energy is the golden thread that connects economic growth, increased social justice, and an environment that enables the planet to progress” [8].

By improving the living standards of rural populations, both qualitatively and financially, smart villages have emerged as a new development model that shares analogous key points with the better-known concept and project of smart cities. The concept and project of smart villages, from the perspective of a modern approach to energy, can be considered as key trigger for initiating progress and ultimately revolutionizing rural areas. They have the potential to bring advancements in healthcare, e-education, drinking water and sanitation management, food standards, business productivity, sustainability, ecological concerns, participation in democracy, and accessibility to energy. By embracing these advancements, the rural population can achieve a healthy and high-quality standard of living, thereby realizing their development goals and developmental potential, as well as be part of the globally connected world through the use of computer networks, leveraging many advantages of urban life while retaining traditional aspects rural life has to offer, giving them the choice between migrating to urban centers or living in a smart village [2]. The key drivers of the developmental benefits in smart villages include the implementation of an electricity source model and the affordability of pollution-free and efficient cooking stoves, all integrated with a focus on sustainability. [2].

Rural areas are susceptible to numerous climate change hazards and natural disasters, such as floods, landslides, droughts, heavy rainfall, strong winds, volcanic eruptions, and tsunamis [3]. They also face risks associated with agrarian market fluctuations, economic volatilities, and outbreaks of epidemics. Climate change tends to intensify these hazards periodically, resulting in frequent natural disasters. In such severe and volatile environments and events, developmental advantages are not only challenging to acquire but also difficult to retain compared to the recent past [3]. Smart village related benefits can provide rural communities much needed resilience and flexibility to the aforementioned hazards [3]. Physical infrastructure, coupled with access to energy, serves as a crucial driver for the implementation of contemporary informational-communicational technologies. These technologies can act as the cornerstone for the adaptation of villages to changing circumstances through [3]:

- Enhancing community-level knowledge through training, education, and the exchange of information, thus creating skills and knowledge on developing resilient infrastructure;
- Establishing communication links and providing resources for pre-disaster warnings, as well as more efficient efforts for disaster response;
- Enhancing healthcare facilities and ensuring adequate and sufficient lighting are especially crucial in villages during and immediately after periods of the aforementioned catastrophes and disasters.

Methodology, Hypothesis, and Sources

The aim of our research is to determine how new technologies in agriculture can contribute to the development of the concept of smart villages.

The methodology of our research is analytical-descriptive. We have studied a large number of literature sources, analyzed them, and drawn appropriate lessons and conclusions. In a multidisciplinary approach (technical, economic, and agro-economic), we have examined the new phenomenon in agriculture - new technologies - and explored their potential applications with the aim of building and implementing smart village models. The main hypothesis of this study is that new technologies applied in modern agriculture can be significant factors for smart villages, a concept that should be developed based on the concept of smart cities.

Smart Agriculture Services

In a smart village, various services can be implemented to improve the quality of life, the living standards of the local population, implement and enhance sustainable development models, and establish efficient resource management. Some of the potential services include: Smart grids and energy efficiency management, Environmental monitoring, Smart agriculture (agriculture 4.0 or 5.0), Smart water management, Smart waste management, Automation of intelligent homes, Improvement of the transportation system, Introduction of E-government.

The service that encompasses multiple aspects of a smart village, in terms of implementing sustainable development models, improving quality of life through automation, enhancing living standards, and efficient resource management, is smart agriculture. Smart agriculture as a service includes technologies such as precision farming tools, various sensors in the soil (e.g. moisture sensors), and crop monitoring systems.

The American National Research Council has provided a definition of precision farming as a "management strategy that uses information technologies to collect data from multiple sources that will influence decisions related to agricultural production" [6]. Another simpler way to define precision farming is "the process of putting the right things, in the right amount, in the right place, at the right time" [7].

Mechanization plays a crucial role in precision farming [4]. Timeliness of work, ease of use, and rational use of inputs are important parameters for increased production. Improving the use of agricultural equipment can increase crop production by 15-20 percent [4]. Certain forms of precision farming have been practiced by farmers since the early days of agriculture (Agriculture 1.0). Agriculture 1.0 developed at the beginning of the 20th century with high human labor involvement and low productivity, where animal-drawn implements dominated as auxiliary tools [4]. The further development of agriculture involves a gradual reduction in the involvement of human labor, with the use of mechanization and increased productivity [4], progressing through Agriculture 2.0 (the so-called Green Revolution), Agriculture 3.0, which introduced the term precision agriculture, up to the present focus on Agriculture 4.0. Agriculture 4.0 represents a smart agriculture service that is significantly developing, not only in terms of increasing market share, but also in terms of innovation and consumption. It includes a system of cheap and advanced sensors and actuators. It consists of the following components: Cheap microprocessors, Broadband network communication infrastructure, Cloud servers (cloud computing), and Big data analytics.

The alternative name for Agriculture 4.0 is Digital Agriculture or Smart Agriculture. This name was introduced when telematics and data management began to combine with the well-known concept of precision agriculture, improving the accuracy of operations [4].

The smart agriculture service network in a smart village includes: A central monitoring system that serves as the core of the smart agriculture network. It is responsible for data analysis, visualization, and decision-making. A Gateway, used to collect data from sensors in the field and transmit it to the central monitoring system. The Gateway acts as a bridge between field sensors and the central system. Sensors deployed throughout agricultural areas to collect various data related to weather conditions, soil moisture, soil electrical conductivity, soil pH, and crop monitoring.

Technical solutions

Specifics of technical solutions include a central monitoring system, a Gateway for collecting and transmitting sensor data, and sensors deployed in the field. The technical solution will depend on factors such as the size of the smart village, available resources, desired level of data analysis, and storage capabilities. The central monitoring system can combine these components to create a comprehensive solution. For example, sensor data can be transmitted to a cloud computing platform for storage and big data analysis.

Subsystem determination

The central monitoring system can utilize big data analytics techniques for processing and analyzing large amounts of data collected from different sensors and devices. Big data analytics helps discover patterns, trends,and provides new perspectives on analyzing collected data.This enables better decision-making based on information quality and improved farm management.

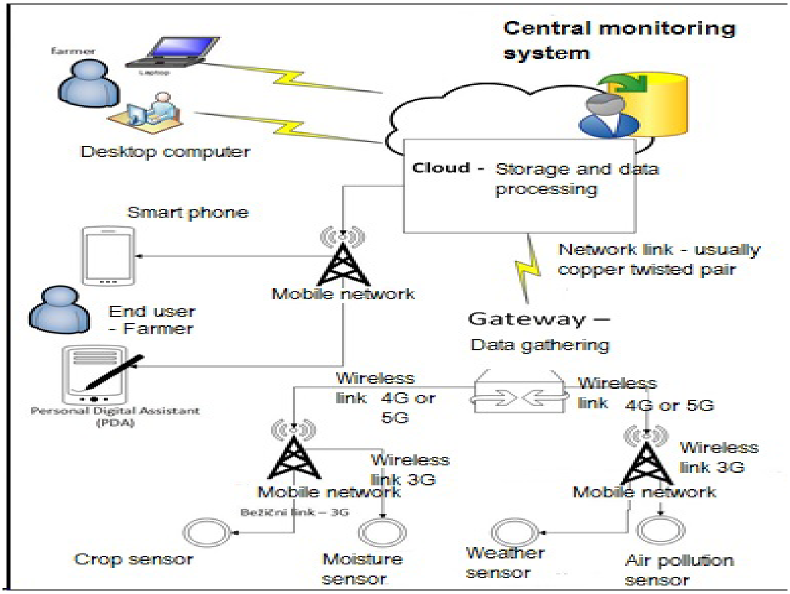
The combination of the central monitoring system with big-data involves using algorithms, statistical models to extract significant information from the collected dataset.

The implementation of a central monitoring system in a smart village can provide multiple services aimed at improving the standard of living for the local population and enhancing the quality and quantity of sustainability models implemented. Among the potential services, smart grids and energy efficiency, environmental monitoring, smart agriculture, water and waste management, automation of smart homes, improvement of the transportation system, and the introduction of e-governance stand out. Smart agriculture is a key service for implementing sustainable development models and effective resource management. This type of agriculture utilizes technologies such as precision tools, sensors for measuring soil parameters, and crop monitoring systems. Timely work and efficient use of inputs are important for increasing crop production. The technical solution for a smart village includes a central monitoring system, data collection Gateway, and field sensors. Communication links can be established through copper wires, optical cables, or wireless technologies such as Wi-Fi, Bluetooth, or Zigbee. Mobile networks like 3G, 4G, and 5G can provide wider coverage for field sensors. The technical solution will depend on the size of the village, resources, and the need for data analysis and storage.

Based on all analyzed information we have constructed a smart village network that includes all necessary and required elements of a smart village model.

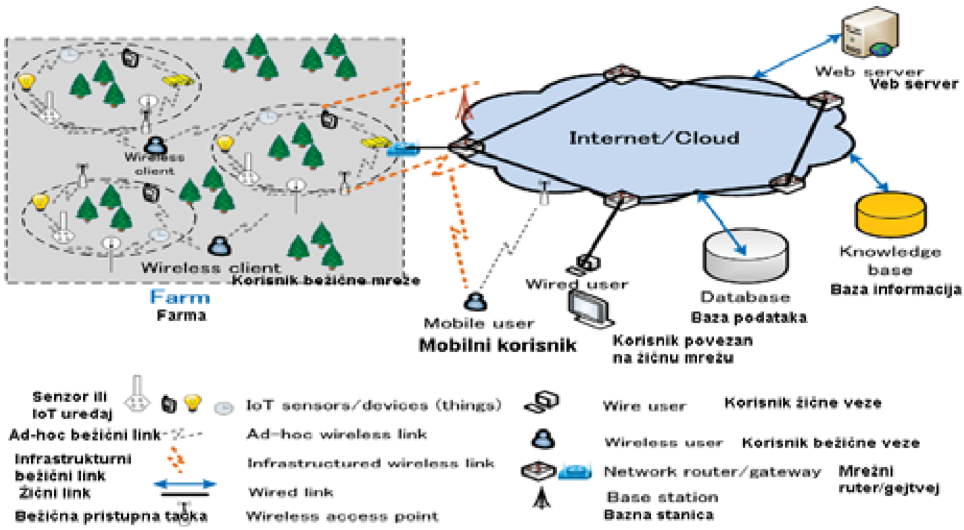
Network diagram of a smart village

Diagram 1: *Smart Agriculture Service Network in a Smart Village*



Source: Authors, diagram created using Microsoft Visio

Diagram 2: *Smart Agriculture Service Networks in a Smart Village*



Source: [9]

Connecting equipment

For long distances between sensors located in the field and the central monitoring system, the following approaches can be considered:

Wireless technologies - Long-range wireless technologies such as mobile networks (3G, 4G, or 5G) should be used for data transmission over long distances. These technologies provide extended coverage and can enable data transmission even in remote areas; Repeaters or Gateways: Installation of repeaters or additional network Gateways is necessary to extend the range of wireless communication. These devices receive data from sensors and forward them to the central monitoring system, bridging the gap between remote sensors and the core network.

Internet connection - If an internet connection is available in the smart village, data can be transmitted over the Internet using protocols such as MQTT (Machine to Machine - M2M network protocol designed for connections with remote locations that have devices with limited resources or limited network bandwidth, such as the Internet of Things), or HTTP (Hyper Text Transfer Protocol). This enables data communication over long distances, making it suitable for remote monitoring and management.

Conclusion

Smart villages offer numerous opportunities for citizens and businesses. If the digitalization of rural areas succeeds, through Internet capabilities such as remote work (home office), e-learning (education from any location), better healthcare (continuous monitoring of blood pressure, etc.), or e-commerce shopping (with fast delivery in the region), rural areas can gain the attractiveness that large cities have, and which they have partially lost [8]. If everything is done properly in this regard - network, devices, services - it would even be possible to slow down or even stop rural exodus. With a powerful Internet connection, there will no longer be a need for people from rural areas to migrate to cities. The first and most basic requirement is stable broadband connectivity for everyone in rural environments, and secondly, appropriate fundamental applications such as e-learning apps in schools and universities, telemedicine, remote work, etc. [8]. In short, new technologies provide great opportunities for revitalizing and developing rural areas in Republic of Serbia, which is also the goal of long-term sustainable development.

Literature

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