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ПРИМЕНЕНИЕ ТЕХНОЛОГИЙ ИНДУСТРИИ 4.0: ИНТЕРНЕТ ВЕЩЕЙ И ИННОВАЦИИ В СЕЛЬСКОМ ХОЗЯЙСТВЕ

Аннотация: *в статье анализируются проблемы применения Интернета вещей в сельском хозяйстве. Изучено его значение для прогнозирования погоды, отслеживания сельскохозяйственной продукции, борьбы с вредителями и болезнями, мониторинга и других инноваций. Тем не менее, в силу ряда проблем в различных реалиях, такие преобразования не наблюдаются. Поэтому были сформулированы рекомендации по борьбе с этими недостатками и выводу слаборазвитого сельского хозяйства на более высокий уровень.*

Ключевые слова: *Интернет вещей, Индустрия 4, сельское хозяйство, устойчивость.*

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INDUSTRY 4.0 ENABLING TECHNOLOGIES APPLICATIONS: INTERNET OF THINGS AND INNOVATIONS IN AGRICULTURE

Abstract: *the present contribution analyses the application problems of Internet of Things in agriculture. Its importance for weather forecast, tracking of farm produce, pests and disease control and monitoring and other innovations were analysed. Still, different realities had not witnessed such reformation and transformation due to some challenges. Therefore, some advices were formulated to combat these lacks and move the underdeveloped agriculture to the higher standards levels.*

Keywords: *Internet of Things, Industry 4, agriculture, sustainability.*

1. *The importance of agricultural sector on the modern stage.*

Agricultural development is one of the most powerful tools to achieve the Sustainable Development Goals and end extreme poverty, boost shared prosperity, and feed a projected 10 billion people by 2050. According to the data of the World Bank

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(2023), growth in the agriculture sector is two to four times more effective in raising incomes among the poorest compared to other sectors. Agriculture is also crucial to economic growth: accounting for 4% of global GDP and in some least developing countries, it can account for more than 25% of GDP. But agriculture-driven growth, poverty reduction, and food security are at risk: multiple shocks from COVID-19 related disruptions to extreme weather, pests, and conflicts are impacting food systems, resulting in higher food prices and growing hunger. Up to 783 million people faced hunger in 2022, which is 122 million more than before the COVID-19 pandemic and 258 million faced acute food insecurity.

The growing impact of climate change could further cut crop yields, especially in the world's most food-insecure regions. The world food systems are responsible for about 30% of greenhouse gas emissions. Current food systems also threaten the health of people and the planet and generate unsustainable levels of pollution and waste. One third of food produced globally is either lost or wasted. Addressing food loss and waste is critical to improving food and nutrition security, as well as helping to meet climate goals and reduce stress on the environment.

Risks associated with poor diets are also the leading cause of death worldwide. Millions of people are either not eating enough or eating the wrong types of food, resulting in a double burden of malnutrition that can lead to illnesses and health crises. Food insecurity can worsen diet quality and increase the risk of various forms of malnutrition, potentially leading to undernutrition as well as people being overweight and obese. An estimated 3 billion people in the world cannot afford a healthy diet.

2. *Internet of Things*: *problems of application in agriculture*

Internet of Things (IoT) being one of the enabling technologies of Industry 4.0 is gaining wide awareness and acceptance in several fields due to its practical relevance in everyday life improvement. IoT has found its utility in transportation, environmental monitoring and forecasting, home and office appliances, agriculture, health, security and energy conservation. However, in some countries, the impact of IoT in agriculture is not conspicuously evident. This might be probably traced to low level of awareness,

illiteracy, poverty, insufficiency or lack of electricity most especially in the rural area where the agriculture is more pronounced.

The IoT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more-direct integration between the physical world and computer-based systems, and resulting in improved efficiency, accuracy and economic benefit. Also known as precision farming, this method of farming uses data analysis to customize operations so as to maximize agricultural output based on variable inputs.

These practices may enable significant opportunities for savings, given that as much as 60 percent of water diverted or pumped for irrigation is wasted. In addition, to ensure food safety, data-driven solutions enabled by the IoT will allow consumers to track and monitor produce from farm to fork.

The IoT is transforming the agriculture industry and enabling farmers to contend with the enormous challenges they face. The industry must overcome increasing water shortages, limited availability of lands, difficult to manage costs, while meeting the increasing consumption needs of a global population that is expected to grow by 70% by 2050. New innovative IoT applications are addressing these issues and increasing the quality, quantity, sustainability and cost effectiveness of agricultural production. Monitor sensors that can detect soil moisture, crop growth and livestock feed levels, manage and control their smart connected harvesters, irrigation equipment, and utilize artificial intelligence-based analytics to quickly analyze operational data combined with 3rd party information, such as weather services, to provide new insights and improve decision making.

Harnessing the potential of all data for economic and social good will be one of the primary challenges and opportunities of the coming decades. A combination of technologies, including low-cost sensors, low-power processors, scalable cloud computing, and ubiquitous wireless connectivity, has enabled this revolution. The decision support systems on farms may combine data on soil conditions from

environmental sensors with historic and future pricing and weather data to produce recommendations to farmers on how to plant and fertilize particular plots of land.

Sustainable agricultural practices help meet immediate societal needs while protecting land and other natural resources for future generations. The Internet of Things is helping to create smart farms where every process can be monitored to reduce waste and improve agricultural productivity. Climate change is inflicting unfavourable condition on agriculture causing set-backs in productivity. However, IoT can help to combat a host of these challenges.

Weather is an important factor to be considered in crop and animal agriculture. Hence, weather forecasting and monitoring must be accurately predicted so as to carry out production activities to time for eventual improved productivity. Animal agriculture is also affected negatively by harsh weather; in terms of reproduction, performance and production. Thus, forecasting and monitoring of weather situations empower the farmer with information that can guide them in planting, harvesting and other production activities to be carried out. Also, policy makers can be fortified with information that will guide their decisions aright.

Weather forecasting can be done through analysis of weather data over long periods to reduce agricultural risk. This is referred to as big data analysis. In weather forecasts for pest management, humidity, precipitation, crop type, soil fertility, leaf wetness, temperature, winds and soil moisture are collected at local level through sensors. The life cycle of pests is monitored along with the climate data, allowing researchers to predict pest outbreaks more accurately because pest maturation depends on environmental conditions.

Temperature, humidity, light intensity, and soil moisture can be monitored through various sensors. These can then be linked to systems to trigger alerts or automate processes such as water and air control. They can also be set up to look for early signs of pests or disease. The use of drip irrigation system for wetting plants eliminates waste of water and fertilizers. Sensors are used to detect the moisture and nutrient deficiencies of plant and soil while the right quantity is allowed to drop where it is needed. As such, under or over

watering is eliminated. This can be said to be precision agriculture and it can lead to great harvest even in dry/drought periods of the year. Crops that are naturally unavailable in dry season can be readily made abundant through this means.

IoT technologies facilitate the tracking of farm products from farm to fork, hence, all individuals involved in production, processing and transportation are fortified with necessary information to discharge their duties. With the advent of IoT, the transporter can be guided to others in the vicinity in need of this service.

Also, smart phones can be equipped with software that can enable internet/mobile banking for both farmers and buyers to encourage cashless transactions. This can be a great intervention for farmers that are mostly rural dwellers where no bank is situated within a reasonable distance. E-banking will also reduce the incidence theft and aid e-purchase of farm inputs. To prevent stock theft, animals are fitted with radio frequency identifiers (RFIDs) that enable tracking of the animal. The position of the animal can be visualised on a map in a control centre through data remitted wirelessly. In rural areas where there is communal grazing, animals tend to get lost. Livestock can be fitted with RFID chips and RFID readers are placed at various monitoring spots to transmit information to the farmer. With soil monitoring systems in the fields, farmers can better predict yield. The accessibility of this information, combined with the farmer's first-hand experience, can lead to better decision-making and a more efficient use of resources-with the overall benefit of better productivity. The overall goal is the same: to use the right amount of resources and reduce waste.

3. *Conclusions.*

The global food challenge necessitates that farmers find better means of feeding the population which is growing with a geometric progression. With Internet of Things, agricultural practices become modern and easy, it improves operational efficiency, drives productivity, creates new revenue sources and, ultimately, makes sustainability synonymous with profit.

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