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AGRICULTURAL IRRIGATION – INNOVATIVE SOLUTIONS

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Abstract
Bulgaria's good soil and weather conditions increase the potential of agriculture and provide good opportunities for quality and sustainable food production. These can be expanded and further improved through the use of innovation in all agricultural activities. Farm irrigation is essential for the food supply and economic development of many countries. Innovative solutions are needed to improve the efficiency and sustainability of agricultural practices. Innovations in agricultural irrigation are essential for sustainable farm development and reducing water stress in the world. They help farmers to improve their harvests and preserve water resources for future generations. Integrating different water sources such as groundwater, surface water, rainwater and wastewater can provide a more sustainable and reliable source of water for farms. Innovations in agricultural irrigation require training and education for farmers to understand how to use new technologies and methods. Governments and financial institutions can provide support and incentives to invest in innovative irrigation solutions. In recent years, aquaponics has become an innovative study of the aquaculture industry.
Aquaponics is an innovation in modern farming, a sustainable micro ecosystem with a controlled environment, combining aquaculture with hydroponics. It is developing at a rapid pace as the need for sustainable food production grows and freshwater and phosphorus supplies decline. Another innovative method to tackle the problem of farm irrigation is aeroponics. It is defined as an aerial water culture system or the science of growing plants without soil or substrate culture. The plant grows in the air with the help of artificial support and no soil or substrate is required to sustain the plant. The roots of the plant are suspended in a closed container in the dark and exposed to the open air to receive nutrient-rich water dispersed through atomizers. The modernisation, rehabilitation and renewal of irrigation systems provides an opportunity to reduce the use of pesticides and fertilisers in line with the Green Deal. It also provides an opportunity for Bulgarian farmers to be competitive with their counterparts in other countries. The effect could be strongest for permanent crops, fruit and vegetable production and livestock farming. The goal of the report is to focus on solutions to the problem of farm irrigation in the country by implementing innovative solutions.
Key words: technology, agriculture, environment, innovation, irrigating
JEL: *O3, Q1, Q5, Q16.*

Introduction

Agriculture is an extremely important economic sector for any country. The efficient and sustainable production of food products is a prerequisite for quality and balanced nutrition of society. At every stage of the supply chain (from the farm to the store) quality control and production of the produce is required. The growing

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trend for organic production on the territory of the country is a positive change, which is also a criterion for increasing the quality of food production. Bioproduction can also be considered as a type of innovation in agriculture, which, in addition to high quality food, also contributes to environmental protection. Innovations in agriculture in Bulgaria are not widespread enough, the main reasons for this are the lack of available information about the innovations offered on the market, the prevailing small size of farms in the territory of the country and the high cost of investment in innovations (Zjeleva V., Mutafov E., 2022). The problems that can arise in agriculture are many and of a different nature. In the present study, special attention is paid to the problem of irrigation of agricultural holdings on the territory of Bulgaria. Innovations successfully implemented in other countries are presented, options are given for solving the problem of agricultural irrigation, by applying innovative solutions. Statistical data from the National Statistical Institute, the Ministry of Agriculture and the State Agricultural Fund are used.

Analysis of agricultural irrigation problems

Water is an essential component of agricultural productivity and is critical to food security. Twenty percent of all agricultural land is used for irrigated agriculture, which generates forty percent of the total food produced globally. The productivity of irrigated agriculture is often at least twice that of rainfed agriculture per unit of land, allowing for greater crop diversification and intensification of production.

Competition for water resources is expected to increase as a result of population expansion, urbanization and climate change, with an emphasis on agriculture (Kirova, 2023). By 2050, the world's population is projected to reach over 10 billion, and whether they live in cities or in villages, they will all need food to meet their basic life needs. This, combined with the increased consumption of healthy and quality food that accompanies income growth in the developing world, it is estimated that agricultural production will need to expand by approximately 70% by 2050. Future water demand in all sectors will require redirecting up to 40% of water from lower to higher productivity and employment activities, especially in water-scarce areas. Due to the significant share of water demand in agriculture, such reallocation is generally expected to originate from this sector.

Today, agriculture uses 70% of all freshwater globally (on average) and much more than „consumptive water use“ due to crop evaporation. Changes in the initial distribution of surface and groundwater resources, primarily from agricultural to urban, environmental, and industrial users, can lead to physical water movement (Totev, Mochurova, Kotseva-Tikova, 2021). In theory, water can also travel, as the production of food, goods and services that require a lot of water is concentrated in water-abundant regions and traded to water-scarce regions.

Improvements in water use efficiency and advances in water supply systems will also need to go hand in hand with cross-sectoral water reallocation and large water

transfers from agriculture. The efficiency of agricultural water use will also depend on how well basic (off-farm) system improvements are matched with appropriate on-farm spending incentives aimed at improving soil and water management. To implement such options, water delivery systems will need to be upgraded to provide adequate services on demand. It will also be necessary to use advanced technologies (such as soil moisture sensors and satellite measurements of evapotranspiration) to increase the productivity and efficiency of water use in agriculture (Kirechev, 2021).

Addressing the challenges of the future requires a thorough review of how water is managed in the agricultural sector and how it can be repositioned in the broader context of overall water management and water security. Furthermore, irrigation and drainage systems, whether large or small, are notable examples of spatially dispersed public works in rural areas. Thus, they represent a logical means of mobilizing employment opportunities in the population. Inadequate policies, severe institutional inefficiencies and financial constraints are often obstacles to improving water management in agriculture. Important governmental and private entities, such as basin directorates, irrigation agencies, water user and farmer associations, ministries of agriculture and environment and water, usually lack basic resources to fulfill their duties.

For example, basin directorates often lack sufficient authority to bring stakeholders together and enforce water allocation. Institutions tasked with irrigation development are often limited to capital-intensive and larger-scale schemes and tend to rely on public sector-based approaches rather than developing opportunities for small-scale private financing and irrigation management (Georgieva S., 2020). Farmers and their organizations also often respond to highly skewed incentive frameworks for water pricing and agricultural support policies, further hindering positive developments in the sector. Furthermore, most governments and water users fail to invest adequately in the maintenance of irrigation systems. Although insufficient management and operation can contribute to the adverse performance of irrigation systems, in particular the inability to maintain them adequately, this is the cause of their reduced productivity and the resulting requirement for rehabilitation. This failure to provide adequate funds to maintain irrigation systems has led to the cycle of „build-neglect-rehabilitate-neglect“ commonly observed in the sector.

Given the existing constraints above, the agricultural water management sector is currently in the process of repositioning itself towards modern and sustainable service delivery. It offers a unique method of managing the risks associated with larger water-related social and economic consequences, while building sustainable water services and maintaining water supplies. This can be achieved by improving incentives for innovation, reform and accountability. It also supports watershed management and the greening of the sector.

Innovative solutions for dealing with the problems of irrigation of agricultural holdings

Since the 1990s, sustainable development strategies have been a global trend, and the circular economy is the general trend of sustainable development and a good way of economic development (Aleksiev G., Doncheva D., 2022). In recent years, aquaponics has become an innovative study of the aquaculture industry.

Aquaponics is an innovation in modern farming, a sustainable micro-ecosystem with a controlled environment, combines aquaculture with hydroponics. It is developing at a rapid pace as the need for sustainable food production increases and freshwater and phosphorus supplies dwindle. As a sustainable, circular, efficient and intensive low-carbon way of production in the future, the aquaponics system realizes the conversion of waste into nutrients and effectively solves the problem of environmental pollution (Wei, Li, An, Li, Jiao, Wei, 2019).

In Aquaponics, more than 50% of the nutrients that support optimal plant growth come from waste from the feeding of aquatic organisms. Integrated aquaculture and aquaponics systems are classified as:

- open,
- homework,
- demonstration,
- commercial,
- projects.

Four scales of production are distinguished:

- under 50 m2,
- from 50 m2 to 100 m2,
- from 100 m2 to 500 m2,
- over 500 m2 (Palm, Knaus, Appelbaum et al., 2018).

By applying aquaponics, vegetable crops do not need fertilization and fish crops do not need frequent water changes. This change allows fish, cultivated crops and microorganisms to form a mutually beneficial symbiosis and harmonious coexistence of relationships of ecological balance. This is a working mode of sustainable healthy food production (Harizanova, Stoyanova, 2016). In the conditions of soil pollution, drought and climate change, aquaponic systems are attracting more and more attention due to the economy of resources, high efficiency and low consumption, and are becoming a trend and development direction of modern agriculture (Stoyanova, Koleva, 2020), (Blagoev, 2022). An example can be given with China, where the largest aquaculture industry is. Aquaculture production exceeds 50 million tonnes, accounting for more than 60% of global aquaculture production in 2018.

The principle of the aquaponic system is that the waste discarded by the farmed fish can be used to break down the ammonia nitrogen in the water into nitrites by mi-

croorganisms. Nitrifying bacteria break it down into nitrates so they can be absorbed as nutrients by the crops being grown and used for growth; thus, the aquatic environment of aquaculture is effectively improved. After the water containing ammonia nitrogen is purified, it can be reused as new aquaculture water through the circulation system, which saves water resources and makes the water exchange efficiency less than 2% per day. Water use efficiency is improved and an ecological cycle of water resources is created. Simultaneously with the growth of the world population and energy costs, the reduction of natural resources such as water and the demand for food contribute to the continuous development of aquaponics systems (Wei, Li, An, Li, Jiao, Wei, 2019).

- As a result of integrated freshwater aquaculture, a variety of methods and system designs have been developed that focus on fish or plant production. In recent years, public interest in aquaponics has grown significantly in line with the trend towards more integrated value chains, greater productivity and less harmful environmental impact compared to other production systems (Palm, Knaus, Appelbaum et al., 2018).
- Another innovative method to deal with the problem of farm irrigation is aeroponics. It is defined as the cultivation system of aerial water culture or the science of growing plants without soil or substrate culture. The plant grows in the air using artificial support and no soil or substrate is required to support the plant. The roots of the plant are suspended in a closed container in the dark and exposed to the open air to receive nutrient-rich water sprayed through sprayers. The upper part of the leaves and the crown of the plant extend above the wetland. The roots and crown of the plant are separated by an artificially created structure. The system uses nutrient-enriched aerial spraying using pressurized nozzles or foggers to maintain hypergrowth under controlled conditions (Lakhair, Gao, Nas Syed, Chandio, Buttar, 2018). The use of aeroponics has many advantages for agricultural production as a modern research tool. The concept of growing plants in the air by providing artificial support dates back to the early 20th century. In 1921 Barker first developed a primitive system for growing plants in the air and used it for laboratory work to study the structure of plant roots. He found that the air plant technique is a natural and simple practice for growing plants without the input of soil. The absence of soil greatly facilitates the study: the roots of plants hang in the air, and the stems are held in an artificial place. In the 1940s, the technique was widely used by many researchers as a modern research tool in plant root studies. Air culture reduces mechanical injury and significant growth disturbance compared to soil, sand or even aerated water culture. Atomizing spray provides a periodic supply of nutrients to plant roots at various periodic intervals for a specified duration, rather than constant misting. The first trials of steam fogging were done on citrus, avocados and apples to investigate plant root

diseases. In California, tomatoes and coffee are grown in a watertight container with a fine nutrient mist driven by a pressure atomizing injector, a method called an „aeroponic plant growing system"(Stoner, 1983). Researchers are of the opinion that the aeroponic system is currently the most effective system for growing plants without the intervention of soil compared to other soilless techniques. The nutrient mist system uses a minimal amount of water and provides an excellent environment for plant growth (Buer, Correll, Smith, Towler, Weathers, Nadler, Seaman, Walcerz, 1996). Scientists are investigating the utility of the aeroponic system for spaceflight and are finding that the system is contributing to advances in several areas of plant root research. Studies include:

- root microorganisms,
- root response to drought,
- impact of oxygen concentration on root growth;
- interaction between legumes and rhizobia;
- production of arbuscular mycorrhizal fungi;
- differences in root growth of plant varieties.

The technology saves water up to 99%, nutrients – 50% and 45% less time compared to growing in soil. Scientists from NASA (NASA, 2006) are of the opinion that in the aeroponics system, plant roots are quickly fed with available nutrients and grow under controlled conditions. Controlled conditions include:

- equal concentration of nutrients,
- EC and pH values,
- temperature,
- humidity,
- light intensity,
- spraying frequency,
- dispersion time,
- spray interval
- presence of oxygen.

The innovative technology is currently used to grow cultivated garden ornamentals, herb roots, and root-based medicinal plant production (Lakhair, Gao, Nas Syed, Chandio, Buttar, 2018).

Conclusion

The modernization, restoration and renewal of irrigation systems enables the reduction of the use of pesticides and fertilizers in line with the Green Deal. It also provides an opportunity for the Bulgarian agricultural producer to be competitive with his colleagues from other countries. The strongest effect could be in permanent plantations, fruit and vegetable production, as well as for animal husbandry. Through the modernization, restoration and renewal of the irrigation systems, the

possibility of supplying water to other industrial productions in the rural areas is also opened. Innovation in the sector is a prerequisite for the inclusion of more young people, through a combination of smart technologies, electronicization, robotics and improved marketing. The result would be an increase and addition of value to the production and catching up of the standard of living from the so-called „rural-type" municipalities to those of the so-called „urban".

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