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SMART WATER MANAGEMENT IN AGRICULTURE - USING INFOWATER PRO SOFTWARE FOR EFFICIENT IRRIGATION

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Abstract. *The sustainable management of water resources represents one of the key challenges in modern agriculture, particularly in regions affected by climate variability and declining groundwater levels. Modern irrigation systems require an integrated approach based on geospatial technologies, smart sensors, and predictive models capable of optimizing water use according to the real needs of crops. This article presents the use of InfoWater Pro, an advanced hydraulic modeling platform developed by Autodesk, for the analysis, planning, and optimization of irrigation networks at the agricultural plot level. The integration of InfoWater Pro with geodetic data (GNSS RTK, UAV surveys) enables the creation of a detailed digital model of the water distribution system. This model allows the simulation of various irrigation scenarios, identification of water losses, and evaluation of hydraulic efficiency across different field conditions. The area studied was a plot of land outside the Didactic Station of ULS in Timisoara with cadastral number A369. An innovative aspect of this research is the use of hydraulic modeling to design an optimal irrigation scheme for the studied plot, enabling accurate estimation of water requirements, flow distribution, and related operational costs. By correlating irrigation timing and volume with the phenological growth stages of crops, water can be applied precisely when and where it is most needed, improving efficiency and yield, ensuring both economic optimization and sustainable water management. Preliminary results indicate the development of an intelligent and sustainable water management model for agriculture, with potential applications in both experimental and large-scale agricultural systems.*

Keywords*: Sustainable, water management, irrigation, Infowater pro, reducing consumption, agriculture*

INTRODUCTION

Water resources are one of the most important production factors in agriculture, directly influencing crop yields and the stability of agro-ecosystem systems. In the current context, marked by climate change, frequent droughts and pressure on natural resources, the implementation of modern methods of efficient water management is essential. Precision agriculture today offers digital solutions that allow monitoring, analysis and control of water consumption according to the real needs of plants and the specific conditions of each agricultural plot.

According to a 2022 United Nations report, the global population is expected to reach 9.7 billion by 2050 (KITOLE et al, 2024). This rapid growth poses significant challenges for agriculture, as arable land continues to diminish and water resources become increasingly scarce, necessitating the adoption of highly efficient and sustainable production techniques. Furthermore, ensuring the equitable distribution of high-quality food, particularly across high-income and developing regions, will become a critical concern (BORDA et al, 2023).

At the same time, the ageing demographic of the farming population adds further pressure to the agribusiness sector. Agriculture has undergone profound transformations over the past decades, shaped by technological innovation, modern management practices, and the transition toward precision and digital farming (NAGENDRAM, 2024). To meet the nutritional demands of a continuously expanding population, especially in developing and underdeveloped countries, there is a growing emphasis on implementing innovative, data-driven, and resource-efficient strategies. In this context, maximizing food production through the optimized use of soil and water resources remains a top global priority (OBAIDEEN, et al, 2022).

Irrigation systems are increasingly challenged to achieve higher productivity with limited water resources. Implementing innovative management and technological practices can enhance economic efficiency while simultaneously reducing environmental impacts, including lower water abstraction, decreased energy consumption, and minimized pollutant discharge (FAURÈS & SVENDSEN, 2007).

Agricultural irrigation ensures that the water required for plant growth is delivered to the soil in a controlled manner. When improperly implemented, irrigation technologies may lead to financial losses for farmers, ultimately reducing the economic water productivity index and undermining overall sustainability (BATTILANI, 2012).

Drip irrigation systems, which have been one of the most efficient methods since the 1970s, are modernized with IoT and artificial intelligence in this study, aiming to both increase efficiency and prevent water waste (ALAOUI, 2023).

A properly designed irrigation system is fundamental to achieving both profitable and environmentally sustainable irrigation practices, in addition, proper design helps to reduce environmental impact by limiting energy consumption, reducing surface and groundwater pollution caused by nutrient or pesticide runoff, and maintaining local hydrological balance. At the same time, the use of modern technologies — such as humidity sensors, satellite monitoring systems, or automatically controlled irrigation — optimizes water application in real time, leading to significant savings and an increase in the economic and ecological sustainability of the farm. (ABREU & PEREIRA, 2002).

In this context, InfoWater Pro, a software solution developed by Autodesk – Innovyze, integrated into the ArcGIS Pro environment, offers a powerful platform for modeling and simulating water distribution networks (AUTODESK, 2024). Through this tool, the user can build detailed hydraulic models, capable of analyzing pressures, flows and water losses from an irrigation network, as well as evaluating the system's performance in different operating scenarios. This approach allows for optimization of water consumption, identification of areas with significant losses and adaptation of the irrigation program according to the real requirements of the soil and crops (AUTODESK INNOVYZE, 2024).

MATERIAL AND METHODS

Land Description

The study plot is located at coordinates N 45° 47′ 23.525″, E 21° 12′ 47.38″, in the west of Romania. The site lies within a region characterized by a temperate-continental climate multi-annual average temperatures are reported around 10-12 °C in many sources for the plane parts of Timiș County. Elevation in the county’s depressions averages around 500 to 650 m above sea level.

Precipitation in the region is moderate to high, with monthly rainfall values reaching 100-125 mm during the early summer months, and annual totals commonly in the range of 650–750 mm or more depending on altitude. Relief is varied: the area features depressions and hills rather than high mountain peaks, with the terrain influencing local hydrology surface runoff, natural drainage patterns, and soil moisture dynamics.

In this context, the agricultural plot benefits from natural rainfall and runoff potential but also faces typical challenges of the region: seasonal variation in precipitation, potential for drought in dry months, and topographic influence on irrigation uniformity and system design.

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These conditions guided the choice of a hybrid irrigation supply system (groundwater + rain-harvest + surface reservoir) and the hydraulic modeling approach described herein.

Soil Characteristics

The soils in Timiș County include types such as preluvisols, luvisols, eutric cambisols and dystric cambisols.

In certain areas, more clay-rich soils classified as pellic vertisols / vertisols (deep clay >30% or >45% clay content) are found (ROGOBETE G., et al, 2022).

Example physical / hydro physical parameters measured in a pasture plot:

- Texture: coarse sand ~3.6 % ; fine sand ~44–46 % ; silt (0.02–0.002 mm) ~24–26 % ; colloidal clay ~24–31 %
- Hydraulic conductivity: ~3 mm/h at the top horizon decreasing to ~1 mm/h in deeper layers.
- Useful water capacity: ~12–14 % in the upper horizons. (Bertici R. et al)

The soil texture and infiltration capacity vary significantly based on horizon depth, local drainage conditions, and clay content. For irrigation design: higher clay (<1 mm/h conductivity) implies slower infiltration and potentially higher risk of surface runoff or ponding; lighter textures (higher sand) yield higher infiltration rates.

Implications for Irrigation Design

Given the above soil data:

The network must account for zones with lower infiltration capacity (e.g., clayey horizons) by adjusting application rates (lower flow / longer duration) to avoid lateral flow or surface runoff.

In lighter soil texture zones (higher sand), faster infiltration but also faster drainage means more frequent irrigation may be required to maintain root zone moisture.

The hydraulic model in Autodesk InfoWater Pro should include infiltration or infiltration-rate assumptions for laterals/emitters based on local soil hydro physical values (e.g., 1–3 mm/h in example site) to size pipes, pumps and schedule accurately.

Storage tanks and reservoirs become more important because soils with low useful water capacity (~12 %) cannot buffer large deficits — prompting more frequent irrigation or relying on stored water to fill system quickly.

Software Description

In this study, the design and hydraulic analysis of the irrigation system were performed using Autodesk InfoWater Pro, a GIS-integrated hydraulic modeling software that operates as an extension within the ArcGIS Pro environment (Autodesk, 2024). The software allows the construction, simulation, and management of water distribution networks based on spatially referenced data, facilitating an integrated approach between geospatial information and hydraulic performance modelling.

InfoWater Pro supports the representation of essential network components such as pipes, pumps, valves, reservoirs, and tanks. It enables the simulation of pressure, flow distribution, energy consumption, and water quality dynamics throughout the system. This functionality allows users to evaluate multiple irrigation scenarios, optimize system performance, and minimize energy and water losses before physical implementation (AUTODESK, 2023a).

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One of the key advantages of using InfoWater Pro lies in its native integration with ArcGIS Pro, which ensures seamless access to geographic data such as digital elevation models, land use, and soil layers. This integration was particularly useful in this study for defining the topography and hydraulic boundaries of the selected plot located in western Romania. The spatial accuracy of GIS data directly enhances the precision of network modeling and hydraulic computations (AUTODESK, 2023b).

Moreover, the software allows for the simulation of pressure-dependent demands (PDD) and leakage modeling, which are critical when designing efficient irrigation networks that must operate under variable field conditions. By assessing system performance under different flow and pressure scenarios, InfoWater Pro supports decision-making toward an economically efficient and environmentally sustainable irrigation layout (AUTODESK, 2023a).

The hydraulic simulations were used to determine optimal pipe diameters, node pressures, and flow distributions within the irrigation network. The resulting model also supported the identification of critical points where water losses could occur or where additional pumping control might be necessary. The outputs were visualized through thematic GIS layers and exported to ArcGIS Pro maps for further spatial analysis and reporting.

RESULTS AND DISCUSSIONS

Irrigation Network Modeling in InfoWater Pro

The irrigation network for the studied plot (total area 237,322 m²) was designed and simulated using Autodesk InfoWater Pro. The model aims to determine the optimal distribution of water resources across the agricultural field while ensuring hydraulic stability, energy efficiency, and adequate pressure at each irrigation junction.

As shown in Figure 2, the network layout consists of primary and secondary distribution pipes (blue lines), with junction nodes (green dots) representing the connection points for irrigation laterals or emitters. The system is supplied by three drilled wells (pink circular nodes labeled *foraj*), each connected to a pumping station (pink square "P" symbols). These pumps ensure the necessary head and discharge to maintain adequate flow rates throughout the distribution grid.

Control valves (yellow icons) are strategically placed along the network to regulate flow, pressure, and sectorization during operation or maintenance. In addition to the drilled wells, the irrigation network integrates alternative water sources designed to enhance sustainability and reduce dependence on groundwater extraction. Two elevated storage tanks (represented by blue tower symbols in Figure 2) function as rainwater harvesting units, collecting and temporarily storing precipitation from nearby infrastructure and natural runoff. This water is then gradually released into the irrigation system, supplementing the supply during periods of moderate demand.

The man-made reservoir located in the northeastern sector of the plot serves a dual purpose. It acts both as a storage basin for excess surface water collected during high rainfall events and as a balancing reservoir that stabilizes flow availability during dry periods. The reservoir receives runoff from surrounding agricultural parcels, effectively recycling surplus water that would otherwise contribute to soil erosion or drainage losses.

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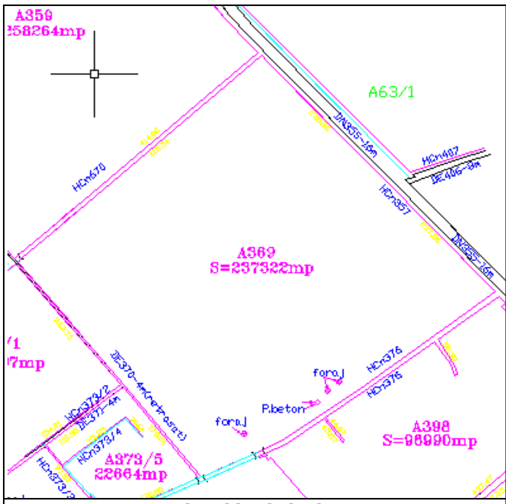

Figure 1. Agricultural land plot location in ULST

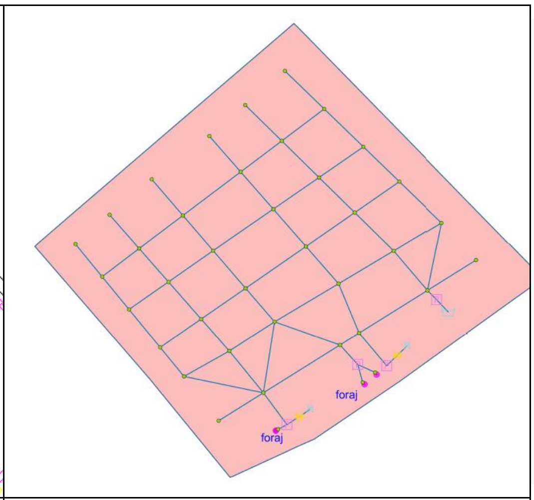

Figure 2. Simulated Water Irrigation Network

By integrating these rain-fed sources with groundwater wells, the system promotes a hybrid water supply model, improving resilience against drought and reducing energy consumption related to pumping. Moreover, the combined use of natural precipitation and reclaimed surface water aligns with the principles of sustainable irrigation management, ensuring both economic and environmental efficiency.

This modeling approach enables precise hydraulic simulation and optimization of irrigation parameters such as pressure distribution, discharge uniformity, and energy consumption. By simulating different operational scenarios, InfoWater Pro helps identify the most efficient irrigation scheme, ensuring full or near-complete coverage of the cultivated surface with minimal water and energy losses.

Overall, the model provides a quantitative foundation for decision-making in irrigation planning, including the estimation of system performance, operational costs, and resource sustainability.

The main purpose of this irrigation network is to save as much water as possible by combining a well-planned layout with natural water collection methods. The system is designed to guide water efficiently from multiple sources, such as rainwater, surface storage, and existing wells, toward the irrigation lines with minimal losses. By using stored or naturally gathered water, the network reduces pressure on underground resources and helps maintain a steady supply even during dry periods.

Table 1

Parameters of the Irrigation Network Components

Tank ID	Type	Bottom Elevation (m)	Initial Level (m)	Min. Level (m)	Max. Level (m)	Diameter (m)
T1	Cylindrical	100	14	3	15	15
T2	Cylindrical	100	14	3	15	15

Pump ID	Type	Diameter (cm)	Elevation (m)	Shutoff Head (m)	Design Head (m)	Design Flow (lpm)	High Head (m)	High Flow (lpm)
P1	Exponential 3-Point	30	28	85	80	122	67	3000
P2	Exponential 3-Point	30	28	85	80	122	67	3000
P3	Multiple Point Curve	50	10	100	85	190	89	5000

Pipe ID	Diameter (cm)	Length (m)	Roughness Coefficient	Minor Loss Coefficient
1-60	25	50-110	125-150	0.00

Valve ID	Type	Elevation (m)	Pressure Setting (bar)	Diameter (cm)	Minor Loss Coefficient
V1	PRV	15	3,4	20	0.00
V2	PRV	15	3,4	20	0.00
V3	PRV	18	5,1	25	0.00

This approach supports sustainable water use in agriculture, ensuring that every part of the field receives only the amount of water needed. The result is a system that is cost-effective, adaptable, and environmentally responsible, balancing productivity with conservation (Figure 3).

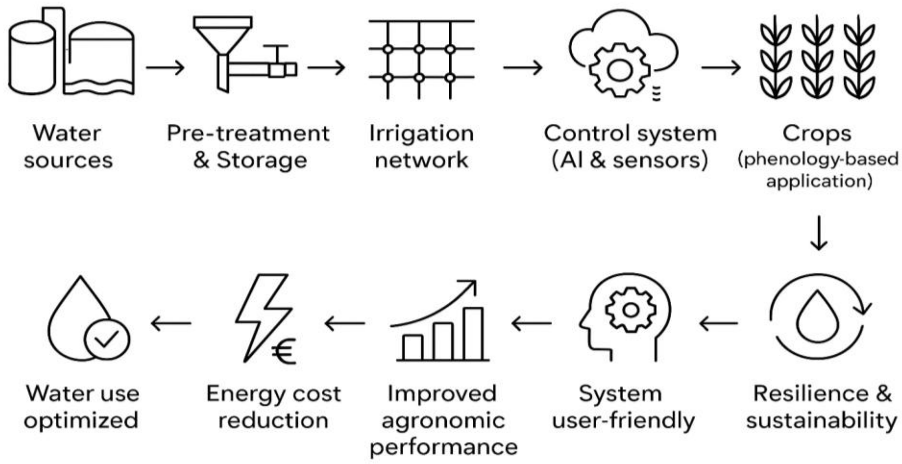

Figure 3. Functional layout and operation flow of the irrigation network

CONCLUSIONS

The use of Autodesk InfoWater Pro in constructing an irrigation scheme offers a significant advantage in terms of precision, visualization, and efficiency. The software enables the designer to create a fully functional hydraulic model. This allows for a detailed simulation of water distribution, pressure balance, and flow optimization across the irrigation network.

Another major benefit lies in its integration with ArcGIS Pro, which allows the system to use real terrain data, elevation models, and spatial coordinates. This ensures that the irrigation design reflects actual field conditions, leading to better decision-making and accurate estimations of water requirements. Additionally, the software supports the evaluation of system performance under varying conditions, making it an invaluable tool for sustainability assessments and long-term planning.

However, there are also some limitations. The accuracy of the results depends heavily on the quality of the data input, for example, elevation, soil infiltration rates, or flow parameters. Simplifications made during modeling (such as uniform soil or crop assumptions) can cause small discrepancies between simulated and real-world performance. Furthermore, the software does not directly account for biological variability in crop water use or microclimatic differences across a field, which may require integration with field sensors or AI-based systems for dynamic control.

Despite these limitations, InfoWater Pro remains a reliable and powerful tool for the design and simulation of irrigation networks. The graphical outputs and analytical results can be trusted, if input parameters are well-calibrated and validated against field measurements. As part of a broader precision agriculture strategy, the software contributes to optimized water management, sustainable resource use, and enhanced irrigation efficiency at both plot and regional scales.

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