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IMPLEMENTATION OF DRONE-ASSISTED IRRIGATION SYSTEMS AS A TECHNOLOGICAL INNOVATION TO OPTIMIZE AGRICULTURE IN EASTERN ROMANIA

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Abstract. *The implementation of drone-assisted irrigation systems represents a cutting-edge innovation with significant potential to optimize agricultural management in eastern Romania, a region characterized by diverse climatic and agronomic conditions. Advances in unmanned aerial vehicle (UAV) technology enable precise water distribution and real-time monitoring using multispectral sensors and aerial imagery, improving water use efficiency, and increasing crop resilience to environmental variability. The main objective of this research is to evaluate the most effective innovative drone-assisted irrigation model for agricultural development in this region. For this reason, a qualitative methodology was followed to compare the DJI Agras T30, DJI Agras T40, and XAG P100 models in terms of operational performance, technical specifications, and relative costs compared to the size of farms that represent part of the country's emerging commercial agriculture (5-10 ha) in Romania so that accurate agricultural data can be determined in a timely manner for informed decision-making and sustainable planning. The results reveal that all drone models in the study fulfill the optimal irrigation purpose for 5-10 hectares of farms. Although the DJI Agras T40 and XAP P100 models have more advanced technology, the DJI Agras T30 model demonstrates ideal performance with an operational capacity of 16 hectares per hour, advanced altitude control systems, wide spray coverage, among other features that make it a very efficient and adaptable option for local agricultural conditions. Its integration with smart mapping systems supports data-driven decision-making, promoting productivity and water conservation. Although its implementation is limited by the permits that must be legally obtained, high initial costs, reduced battery life, maintenance, and specialized training, drone-assisted irrigation systems are a viable and strategic approach to improving water efficiency, sustainability, and competitiveness in the agricultural sector of eastern Romania.*

Keywords*: agriculture, water deficit, drones, UAV, assisted irrigation, eastern Romania*

INTRODUCTION

Water is one of the most important resources on the planet for the survival of living beings; it is also the main component for ensuring food availability for the population. It is estimated that 97.5% of the water on planet Earth is saline and only 2.5% is fresh water; however, only 31% of the percentage of fresh water can be used because the rest is immobilized in glaciers, making groundwater the largest remaining component of fresh water and the main source of supply for many countries, such as Romania (WORLD BANK, 2021). Currently, Romania has 6% water stress; however, although this figure means that water use is sustainable, it may also mean that the country does not have the capacity to properly manage water resources to satisfy the entire population (WORLD BANK, 2021, SMULEAC ET ALL., 2024). On the other hand, it is recorded that 36.25% of the fresh water available for agriculture is consumed in this country, of which between 2,000 and 5,000 liters per capita are required for one person to produce food; in other words, the availability of fresh water is very minimal (WORLD BANK, 2021; WORLD BANK GROUP, 2022).

This study focuses on the eastern zone covering the northeastern counties of Bacău, Botoșani, Iași, Neamț, Suceava, and Vaslui, which belong to the historical region of Moldavia, and the southeastern counties of Brăila, Buzău, Călărași, Constanța, Galați, Ialomița, Tulcea, and Vrancea, located near the Danube and the Black Sea. These regions coincide with two important river basins: those of the Prut and Siret rivers. According to the Water Framework Directive 2000/60/EC, the main basin is the Prut River, which has seven groundwater bodies: six national and one shared with Moldova (QUEVAUVILLER, 2007). The study by Minea et al. (2020) analyzed the groundwater exploitation index (GWEI) and found a notable increase in human impact in recent decades, associated with the growth of agricultural activity and the increase in groundwater extraction through individual wells for crop irrigation, thus further reducing the amount of groundwater.

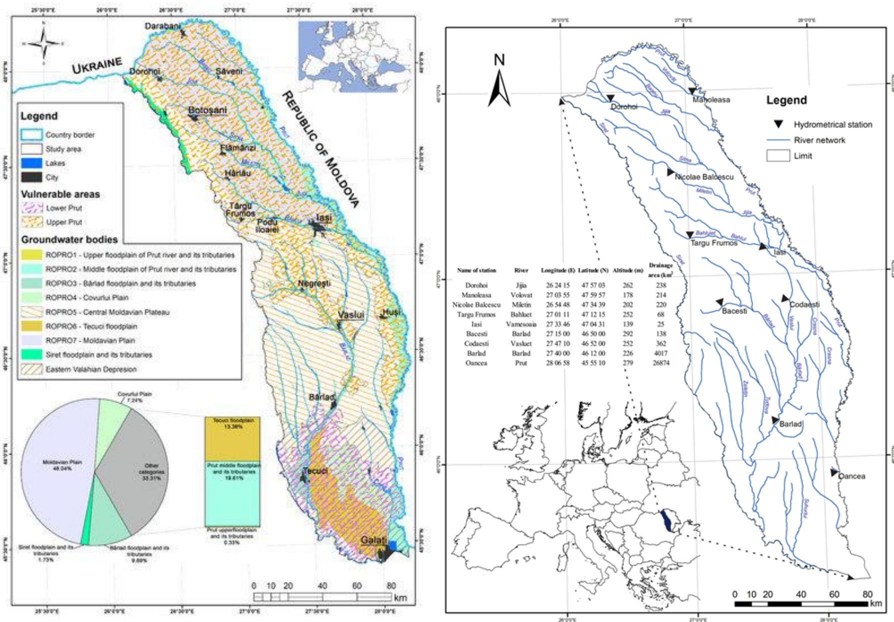

Figure 1: Groundwater and river sources in eastern Romania.
Note: Retrieved from MINEA ET AL. (2020) AND MINEA, I., & CHELARIU, O. (2021).

On the other hand, eastern Romania is characterized by extensive agricultural land, requiring technological innovations to improve irrigation efficiency, conserve water, and increase crop productivity. As shown in Tabel 1, the southeastern region accounts for a high percentage of agricultural activity in the country, representing 65.06%, while the northeast contains 57.66% of the total land (TUDOR ET AL., 2022). For this reason, given the large area covered by agriculture and water shortages, there is a need to distribute limited water resources evenly using drones or UAVs (unmanned aerial vehicles) equipped with multispectral and thermal sensors. In this context, drones are a key tool in agriculture in the face of water scarcity through real-time monitoring of soil moisture and plant health, optimizing water application and thus reducing waste and greenhouse gas emissions by replacing fuel-intensive machinery in certain agricultural operations (MAGHIARI ET AL., 2025).

Table 1

Percentage of area used in each region of Romania

Total/Region	Agr Area/Total Area (%)	Arable Area/Total Area (%)	Arable Area/Agr Area (%)
TOTAL	61.37	39.41	64.22
Region NORTH-WEST	60.87	29.90	49.12
Region CENTRE	55.73	22.02	39.51
Region NORDTH-EAST	57.66	37.50	65.03
Region SOUTH-EAST	65.06	51.14	78.61
Region SOUTH-MUNTENIA	70.63	57.15	80.91
Region BUCHAREST—ILFOV	57.38	55.27	96.31
Region SOUTH-WEST OLTENIA	61.50	42.86	69.68
Region WEST	58.19	34.05	58.51

Note: Retrieved from TUDOR ET AL. (2022).

MATERIAL AND METHODS

This research thoroughly analyzes the existing literature, paying special attention to studies on the implementation of drones for irrigation in agriculture in eastern Romania. For this reason, the qualitative method was used to analyze and synthesize the information found in specialized literature in order to compare the different technologies. The qualitative method is a fundamental tool that allows researchers to understand the context of reality and thus verify how people live in various situations to be investigated from a holistic perspective (GUZMÁN, 2021). Within this framework, this scientific article describes three models of agricultural drones: DJI Agras T30, DJI Agras T40, and XAG P100. In addition, it describes the economic costs and current regulations for the use of assisted drones for irrigation.

The selected articles and studies were identified in specialized scientific journals covering the period from 2020 to the present, such as ResearchGate, Google Scholar, ScienceDirect, among others. In addition, it should be noted that the search was conducted in English, Spanish, and Romanian using the keywords "agriculture," "water deficit," "drones," "assisted irrigation," "eastern Romania," "DJI Agras T30," "DJI Agras T40," and "XAG P100."

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RESULTS AND DISCUSSIONS

Types of agricultural drones used for crop irrigation

Table 2

Comparative table of irrigation drones for crops

Data/Model	DJI Agras T30	DJI Agras T40	XAG P100
Specifications/Advantages	- Spreading tank volume: 30 L - Spray width: 9 m - Total weight (without batteries): 26.4 kg - Maximum take-off weight: 78 kg (near sea level) - Flight time: 20 to 25 minutes - Maximum range: 7 km - Wind resistance: 12 m/s - Intelligent motor for 3D operation planning - Intelligent altitude control - High-precision radar and flow meter - Frequent speed control to avoid falls or collisions with plants.	- Spreading tank volume: 40 L - Spray width: 11 m - Total weight (without battery): 38 kg - Maximum take-off weight for spraying: 90 kg (at sea level) - Flight time: 6 to 18 minutes - Wind resistance: 6 m/s - It contains sensors to avoid obstacles - Good spray width - 3D-Operating planning (AI-intelligent engine) - EFI generator with 15% fuel savings - Integration with mapping and flight planning systems, allowing application in heterogeneous areas.	- Spreading tank volume: 40 L - Spray width: 1012 m - Total weight (payload system excluded and batteries included): 39.6 kg - Maximum take-off weight for spraying: 88 kg (at sea level) - Flight time: 25 minutes - Maximum range: 8 km - Wind resistance: 10 m/s - AI-controlled smart spraying - Durable design - Increased payload capacity
Disadvantages	- Limited battery life - Small fuel tanks compared to ground-based machinery - Requires constant recharging and refueling - Less effective in very large areas	- Short battery life. With a full tank: 6 to 7 minutes. Empty tank: 18 minutes. - Heavier compared to the previous version (DJI Agras T30).	- High energy consumption - Difficult-to-use interface
Operational performance	16 hectares/hour	21 hectares/hour	20 hectares/hour
Relative price	$15,000 to $18,000	$25,000 to $35,000	$15,000 to $19,000

Note: Own study based ON PREDA ET AL. (2025), MAGHIARI ET AL. (2025), DE KOFF AND HOWARD (2025), AND MAMCHUR AND STUDINSKA (2024).

A comparative analysis was conducted between the most effective models on the market for assisted irrigation drones, such as DJI Agras T30, DJI Agras T40, and XAG P100, in various scientific articles (Table 2). All models demonstrated uniform irrigation of the water contained in the tanks of each drone model. It should be added that all of them also have the functionality of irrigating with pesticide solutions; however, one of the most notable differences is their operational performance in terms of total coverage area. For this reason, in order to determine the effectiveness of drones in assisting with crop irrigation, the approximate size of most farms in eastern Romania was compared to determine the ideal irrigation drone option for improving agriculture in the region.

Size of agricultural holdings and operational capacity of drone-assisted irrigation systems

In Romania, according to data from the European Commission (2022), in 2020 it was found that around 90.3% (2.6 million farms) of all farms have around 5 hectares and only 0.9% exceed 50 hectares. On the other hand, more specifically in the case of eastern Romania, the agricultural census recorded a total of 387,864 farms with an area of 0.5 hectares, which shows a marked concentration of micro-scale farms. This value far exceeds the upper ranges, including the 0.5 to 1 ha class, which comprises 156,614 units, followed by the 1 to 2 ha category, with 155,084 farms, and then the 2 to 5 ha class, which comprises 134,616 units. Finally, the 5 to 10 ha range (35,587 farms) will be the subject of analysis in this paper because it represents part of the country's emerging commercial agriculture, which in turn is affected by water scarcity (INSSE, 2022, p. 58).

In this regard, as shown in Table 3, in eastern Romania, there are a total of 35,587 farms registered, with the highest proportion concentrated in the northeast, which accounts for 20,990 farms, with the counties of Suceava, Botoșani, and Bacău standing out as the territories with the highest number of medium-scale agricultural units. In the southeast, with 14,597 farms, the counties of Vrancea, Buzău, and Galați stand out, with the largest amount of agricultural land within this range, thus reflecting greater operational capacity, which positions them as units with the greatest potential for progressive technification within the regional agricultural system (INSSE, 2022, p. 58).

In order to determine the effectiveness of drones for irrigation, certain scientific articles were reviewed that used the DJI Agras T30, DJI Agras T40, and XAG P100 drone models. The DJI Agras T30 model has greater coverage towards the center of the strip than towards the outer sections and, above all, demonstrated better coverage at higher altitudes (3 m) (BYERS, 2024). Likewise, another study found that the speed of the drone directly affects the dispersion of the liquid, as distribution decreases when the flight speed of the assisted irrigation drone increases (BYERS ET AL., 2024).

Regarding the DJI Agras T40 model, a study was conducted at Hacienda Santa Luzia, in Cristalina, Goiás state, Brazil, on the effectiveness of spraying; however, this model reveals approximate results of water dispersion in this case. The research showed that the model has an effective spray range of 10 meters and provides greater uniformity at an altitude of 4.5 meters than at 3.5 meters (de Paula Oliveira et al., 2025). On the other hand, it was found that high application volumes (28 L/ha) and low flight speeds (4 m/s) result in greater coverage in the field, while higher flight speeds (10 m/s) cause a reduction in spray deposition, regardless of the application volume (CAPUTTI ET AL., 2025).

Finally, the XAG P100 has the unique feature of a centrifugal atomizing nozzle system (RevoSpray) that allows the droplet size to be adjusted from 60 to 400 μm, ensuring uniform and precise irrigation coverage of crops (BYERS ET AL., 2024; JANOSZ, ET AL., 2024).

Among the most notable features of drones, the XAG P100 model stands out for its AI-controlled intelligent spraying, which ensures better irrigation (MAGHIARI ET AL., 2025). In contrast, the DJI Agras T30 and DJI Agras T40 models only integrate AI into the use of the engine for 3D operational planning, which allows for better distribution of stored energy. As stated by MAGHIARI ET AL. (2025), AI in drones allows real-time data analysis for precise irrigation in the areas of cultivation that need it most. It also allows for the timely identification of pests and the prediction and planning of crop yields, enabling optimal decisions to be made to improve crop health. DJI is also recognized as the best in the drone and camera technology industry.

Table 3

Number of hectares of farms in eastern Romania by macro-regions.

	Under 0.5	**0,5-1**	**1-2**	**2-5**	**5-10**	**10-20**	**20-30**	**30-50**	**50-100**	**20-30**	**100-500**	**500-1000**	**TOTAL**
MACROREGION	***387,864***	***156,614***	***155,084***	***134,616***	***35,587***	***14,842***	***5,844***	***5,464***	***3,450***	***4,588***	***691***	***332***	**904976**
Northeast	240,289	110,095	108,539	90,248	20,990	8,144	3,096	2,820	1,387	1,683	228	112	**587631**
Bacău	45,937	22,895	19,060	12,877	2,629	893	367	375	213	237	21	7	**105511**
Botoșani	31,737	12,193	15,014	16,463	4,739	1,805	720	616	234	330	49	29	**83929**
Iași	50,302	15,853	13,299	10,227	2,487	1,159	534	521	243	366	64	34	**95089**
Neamț	36,694	16,112	17,056	13,291	2,393	753	311	340	256	234	27	12	**87479**
Suceava	42,360	29,303	31,675	27,195	6,262	2,452	692	394	213	135	13	9	**140703**
Vaslui	33,259	13,739	12,435	10,195	2,480	1,082	472	574	228	381	54	21	**74920**
Southeast	147,575	46,519	46,545	44,368	14,597	6,698	2,748	2,644	2,063	2,905	463	220	**317345**
Brăila	13,149	1,883	3,039	5,076	2,480	1,230	478	401	360	497	63	35	**28691**
Buzău	35,821	13,219	13,288	11,681	3,066	1,012	437	376	322	392	79	32	**79725**
Constanța	13,888	1,485	1,492	2,658	2,082	1,408	580	582	450	781	148	77	**25631**
Galați	40,119	9,835	9,375	8,215	2,220	1,012	469	482	306	427	65	30	**72555**
Tulcea	16,670	2,544	2,290	2,647	1,552	1,058	472	506	425	584	83	33	**28864**
Vrancea	27,928	17,553	17,061	14,091	3,197	978	312	297	200	224	25	13	**81879**

Note: Reprinted from "General data of the general agricultural census 2020, and counties" by INSSE (2020).

In the study by BORYCHOWSKI ET AL. (2020), the resilience of 809 small-scale farms in Romania was assessed, with an average study area of 8.34 hectares. Mathematical calculations showed that the country has an average resilience of 0.518, thus demonstrating that the scale of production is the key determinant of resilience, establishing that smaller farms tend to be more vulnerable. However, they demonstrated high resilience to economic and social changes, such as improving water management and investing in modern irrigation technologies. This demonstrates that farmers would be willing to invest in drones with irrigation systems in order to avoid future crop losses.

In Romania, companies such as Top Geocart, DroneHub Romania, and Romanian Precision Agriculture Solutions (RPAS) collaborate with research institutions and government agencies to provide farmers with access to drones, technical support, and training programs, which helps to promote the adoption of this technology in the country. In fact, a cost-benefit analysis was carried out on sunflower fields, which verified that there was a significant reduction in water use and irrigation costs that offset the initial investment; in other words, there is high economic viability in investing in this technology (MAGHIARI ET AL., 2025).

Based on the analysis presented above, it has been determined that all drones are suitable for irrigating crops when necessary. Although the XAG P100 model features more advanced technology and a more durable design, the DJI Agras T30 and DJI Agras T40 models are also good options, especially for farmers with farms ranging from 5 to 10 hectares because they do not require highly sophisticated models to perform the function of crop irrigation. For this reason, it is suggested to use the DJI Agras T30 model, which costs between $15,000 and $18,000 and covers an area of 16 hectares per hour (30-liter tank). It can also be adapted to spray pesticides to protect crops by controlling pests, weeds, and plant diseases.

Legislation for the use of drone-assisted irrigation systems

The current regulatory framework in Romania, aligned with the guidelines of the European Union Aviation Safety Agency (EASA) under regulation (EU) 2019/947, allows the use of drones for agricultural purposes under the supervision of the Autoritatea Aeronautică Civilă Română (AACR) and with the necessary authorizations from the Ministry of Agriculture and Rural Development (MADR) if pesticides need to be sprayed during the process (table 4). In other words, any type of RPAS (Remotely Piloted Aircraft System) /UAV/UAS with a takeoff weight greater than 25 kg must be registered by the operator and obtain an RFID (radio frequency identification device) issued by the AACR, which must contain the following series: YR-Dxxxx, where x is a digit from 0 to 9 (VLADUT ET AL., 2020).

In this context, the use of agricultural drones such as the DJI Agras T30, T40, and XAG P100 models in eastern Romania is legally viable within the specific category, provided that operators have the appropriate certification and insurance, as this is a category for dangerous flights near people. In addition, drones cannot operate near airports, military zones, or densely populated areas without special approval. Circular drones equipped with cameras are also prohibited to protect individual privacy and prevent data collection; they must comply with GDPR regulations (MAGHIARI ET AL., 2025).

Table 4

Comparative table between European Union and Romanian legislation on the use of drones for irrigation

Regulation Aspect	European Union	Romania
Regulatory Authority	EASA - European Union Aviation Safety Agency	AACR - Autoritatea Aeronautică Civilă Română)
Applicable Laws	EU Regulation 2019/947 & EU Regulation 2019/945	National Law following EU regulations and AACR directives
Drone Categories	Open, Specific, Certified	Follows EASA categorization
Drone Registration	Required for drones over 250g or with a camera	Required for drones over 250g or with a camera
Pilot certification	Required for Specific and Certified categories	Required for commercial and agricultural use
Operational Restrictions	No-fly zones near airports, military areas, crowded places	Same restrictions as EU plus additional national security zones
BVLOS	Allowed with special authorization	Allowed with AACR approval
Insurance Requirement	Mandatory for Specific and Certified category operations	Required for professional and commercial use
Privacy Regulations	Must comply with GDPR	Must comply with GDPR and additional national privacy laws
Commercial Use	Allowed with appropriate category authorization	Allowed with AACR registration and authorization
Agricultural Use	Allowed with permits for pesticide spraying or high-risk operations	Allowed, but requires specific authorization from AACR
Type of Permits Required	**Open Category:** No permit needed (but pilot training required for subcategories A2 & A3) **Specific Category:** Operational Authorization based on risk assessment (SORA) **Certified Category:** Special certification for high-risk operations (e.g., drone delivery)	**Open Category:** No permit needed for A1-A3, but online training required for A2 **Specific Category:** Authorization required for riskier flights (e.g., BVLOS, flying near people) **Commercial Use:** AACR-issued Remote Pilot License **Pesticide Spraying:** Special permit from Ministry of Agriculture **Photography/Surveillance:** Authorization required if images are used commercially or for mapping

Note: Retrieved from MAGHIARI ET AL. (2025).

CONCLUSIONS

This study has demonstrated that the implementation of drone-assisted irrigation systems is a viable and sustainable solution for optimizing water resources, monitoring crops, and increasing productivity, specifically on small farms in eastern Romania. In addition, the comparative analysis identified that all models are capable of drone-assisted irrigation; however, the DJI Agras T30 model is the most suitable for the characteristics of the region and the size of the farms in this study (5-10 hectares), which represent part of the country's emerging commercial agriculture.

However, the articulation and implementation of integrated policies that include government financial support, specialized technical training, and a clear regulatory framework are required to ensure widespread adoption that minimizes annual crop losses. In this context, companies such as Top Geocart, DroneHub Romania, and Romanian Precision Agriculture Solutions (RPAS), in collaboration with research institutions and government agencies, provide farmers with access to drone purchases, technical support, and training programs in order to adopt this technology. Furthermore, to implement this technology, the corresponding permits must be requested, the operator must be registered, and an RFID (radio frequency identification device) must be obtained, which will be granted by the Autoritatea Aeronautică Civilă Română (AACR); especially if the remotely piloted aircraft system/UAV exceeds a takeoff weight of 25 kg.

In conclusion, this study represents a strategic investment vision that is fundamental to the modernization and future of the agricultural sector in eastern Romania. Nevertheless, from a technical standpoint, the implementation of this technology in this region represents an innovation geared toward precise irrigation and efficient water resource management, rather than a replacement for conventional irrigation systems.

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