Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. XV, 2026
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

LONG-TERM CHANGES IN AREAS EQUIPPED WITH DRAINAGE AND DEWATERING SYSTEMS UNDER DIFFERENT LAND USES

Mihaela BALAN[1], Oana Alina NIȚU[2], Cristian POPESCU[1]

[1]University of Craiova, Faculty of Agronomy, 19 Libertatii Street, Craiova, Romania
[2]University of Agronomic Sciences and Veterinary Medicine of Bucharest,
59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: oanaalinanitu1111@gmail.com

Abstract

This paper examines long-term changes in agricultural and non-agricultural areas equipped with drainage and dewatering systems, which are essential for managing excess moisture and maintaining land functionality. The analysis is based on official national statistical data, complemented by relevant scientific literature, and covers a period of approximately 28 years. The study investigates both the temporal evolution of equipped areas and the influence of different land-use types on hydrological regimes, soil properties, and the operational efficiency of drainage infrastructure. The results indicate an overall declining trend in equipped areas, particularly pronounced for arable land, accompanied by structural shifts among land-use categories. These changes are primarily associated with the progressive degradation of hydrotechnical systems, insufficient financial investment, and land ownership fragmentation. The findings underline the need for integrated drainage and land-use management strategies adapted to current environmental conditions in order to sustain agricultural productivity, protect soil resources, and strengthen the resilience of agroecosystems to climatic variability and the increasing occurrence of extreme weather events.

Key words*: dewatering systems, drainage, dynamics, excess moisture, improved land, land reclamation.*

INTRODUCTION

Soil represents a fundamental component of terrestrial ecosystems and one of the most valuable natural resources for sustaining the existence and development of human society. Through its multiple functions - support for agricultural production, reservoir of water and nutrients, and medium for biological activity - soil plays an essential role in ensuring food security and ecological balance (David et al., 2018; Balan et al., 2024). However, soil is a limited and vulnerable resource, exposed to a wide range of degradation processes that require appropriate protection measures and sustainable management (Musat et al., 2021; Corcheș, 2023; EC Law).

Among the degradation processes with major impact on agricultural productivity is excess moisture, a phenomenon that may occur both at the soil surface, in the form of temporary or permanent waterlogging, and within the soil profile, through groundwater rise or deficient internal drainage. Excess water directly affects the air–water balance in the soil, generating a succession of unfavorable changes in its physical, chemical, and biological properties, with negative consequences for plant growth and development (Lațo et al., 2022; Popescu & Balan, 2024; Yang et al., 2025; FAO, n.d.).

From a pedological perspective, the prolonged presence of excess water leads to the reduction of air-filled porosity and limitation of oxygen diffusion in the root zone, favoring the occurrence of anaerobic conditions (Dollinger, 2016; Baborowski et al., 2021; Nițu et al., 2024). Under such circumstances, processes of gleying and pseudogleying are stimulated, soil structure degrades, and hydraulic permeability decreases (Dollinger, 2016; Birkáš et al., 2021). In advanced cases, excess moisture may contribute to the occurrence of secondary salinization phenomena and to a pronounced decline in the productive capacity of agricultural soils (Manik et al., 2019; Nițu et al., 2024; FAO, n.d.).

The geomorphological diversity and variability of hydrological, hydrogeological, and pedological conditions determine, at national level, a high incidence of land affected by excess moisture, requiring systematic land reclamation interventions. According to

assessments carried out by the Academy of Agricultural and Forestry Sciences, approximately 8.62 million hectares of agricultural land are influenced by this phenomenon: 4.2 million hectares by temporary excess generated by precipitation, 1.97 million hectares by shallow groundwater contribution, and 2.45 million hectares by floods or lateral infiltration from watercourses. Of the total, about 4.55 million hectares require proper drainage, while the remaining areas require differentiated measures depending on irrigation regimes and soil particularities (saline, alkaline). In years with normal pluviometric conditions, excess water affects approximately 5.53 million hectares, predominantly located in floodplains and on heavy clay soils. The major determining factors are: precipitation input under reduced evapotranspiration conditions, deficient natural drainage, and low terrain slopes (De Wrachien & Mambretti, 2012; Lațo et al., 2022).

Under Romania's specific climatic conditions, excess moisture occurs predominantly during spring and early summer, directly interfering with agricultural operations and crop establishment. This leads not only to technological delays but also to quantitative and qualitative production losses (Kulshreshtha & Elshorbagy, 2017). Moreover, global climate change increases the frequency and intensity of extreme meteorological phenomena, raising the risk of floods, prolonged water stagnation, and rapid alternation between episodes of excess moisture and periods of pedological and atmospheric drought (Ilie et al., 2012; Bonea, 2020; Nițu et al., 2025).

In this context, dewatering and drainage works have represented and continue to represent fundamental instruments for managing excess moisture and improving affected agricultural land. Dewatering primarily aims at evacuating stagnant surface water through open channels and land shaping, whereas drainage seeks to remove water from the soil profile and control the groundwater level through subsurface drains or absorbent pipes.

In Romania, dewatering and drainage works experienced significant development over time, reaching a peak in the 1980s, when extensive agricultural areas were integrated into complex hydrotechnical systems. After 1990, however, the existing infrastructure underwent a pronounced degradation process, estimated at 60-80%, due to reduced investments, insufficient maintenance, and land ownership fragmentation resulting from restitution processes (Ursu, 2014). This degradation considerably reduced the efficiency of drainage-dewatering systems and amplified the vulnerability of agricultural land to excess moisture.

Specialized literature highlights that degradation of drainage networks leads to increased frequency of temporary waterlogging, secondary compaction, reduced soil aeration, and diminished microbiological activity, with direct impact on fertility (Skaggs et al., 2012; Ritzema, 2016; de Wit et al., 2022). Furthermore, land-use changes significantly influence water balance, surface runoff, and nutrient transport processes (Blann et al., 2009).

Considering these aspects, the present paper aims to analyze the evolution of areas equipped with dewatering and drainage works, by land-use category at national level, over a 28-year period (1997-2024), based on recent statistical data. The analysis seeks to identify major trends, evaluate the magnitude of changes, and highlight their implications for the functioning and sustainability of agro-systems in Romania, within the current context of climate change and socio-economic pressures.

MATERIALS AND METHODS

The study regarding the current situation of land equipped with works for combating excess moisture was based on the use of official statistical data series, supplemented by information from specialized literature. The main sources were the National Institute of Statistics, the National Agency for Land Reclamation, and the Ministry of Agriculture and Rural Development.

For characterizing the recent stage of developments, average values corresponding to the 2020–2024 interval were used, while for highlighting the temporal evolution, reference data for the years 1997, 2007, and 2017 were analyzed. The integration of these benchmarks allowed the outlining of a dynamic image of the changes recorded over approximately 28 years.

The processing of information aimed at quantifying the share of different land-use categories within the equipped areas, applying the percentage method for the synthetic expression of results. In parallel, data interpretation was supported by reference to existing scientific contributions, in order to understand the structural and functional framework of dewatering and drainage works.
The analytical methodology included: descriptive statistical analysis, used to highlight levels, distributions, and trends of the equipped areas; as well as comparative analysis, through which differences between reference periods and the directions of evolution of land reclamation infrastructure were evaluated. Through this approach, the performance of dewatering and drainage works was assessed from the perspective of quantitative dimension and transformations produced over time.

RESULTS AND DISCUSSIONS

According to Table 1, the average values for the 2020-2024 interval highlight the existence of a total area equipped for combating excess moisture of 3,198,803 ha, of which the agricultural component amounts to 2,949,913 ha (92.22%).

Table 1. Situation of land equipped with dewatering and drainage works (Average 2020-2024)

No.	Land use category	Area* -ha-	% of total equipped**
1	Total equipped area	3,198,803	100
2	Equipped agricultural area	2,949,913	92.22
3	Arable land	2,553,962	79.84
4	Natural pastures	256,820	8.03
5	Natural hayfields	109,943	3.44
6	Vineyards and vine nurseries	15,676	0.49
7	Orchards and fruit nurseries	13,512	0.42
8	Equipped non-agricultural area	248,890	7.78

* http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table (15.12.2025)
**Own calculations

The data confirm the predominantly agricultural orientation of dewatering and drainage infrastructure, while non-agricultural land represents a marginal share of only 7.78% (Figure 1).

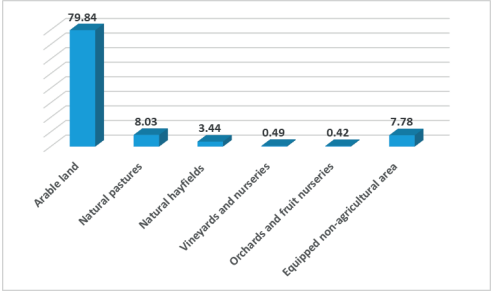


Figure 1. Structure of areas equipped with dewatering and drainage works

Within the equipped agricultural fund, the structure is strongly concentrated in the arable category, which totals 2,553,962 ha, representing 79.84% of the total area. This dominance indicates the historical direction of investments toward land with the greatest contribution to crop production and high exposure to risks generated by water stagnation. Practically, the functionality of dewatering and drainage systems becomes critical for the stability of the major segment of agricultural production.
Natural pastures and hayfields together account for approximately 11.47%, suggesting a secondary importance granted to these uses compared to field crops. At the opposite pole, permanent plantations (vineyards and orchards) hold subunitary shares, each below the 1% threshold. The distribution may be correlated with the frequent location of these categories in hilly or mountainous areas, where natural drainage is more efficient and the necessity for extensive technical interventions is lower.
From a systemic perspective, the overwhelming concentration of developments within the arable area implies a major dependence of national agricultural performance on the technical condition of existing infrastructure. Any process of degradation, underfunding of maintenance, or loss of functionality may generate disproportionate effects on production

volume. The current configuration of areas also reflects the evolution of scientific concepts and development practices, which favored systematic interventions in regions characterized by persistent excess moisture and high agricultural potential.

The evolution of areas equipped with dewatering and drainage works was marked by accelerated expansion in the second half of the twentieth century. If in 1944 approximately 358 thousand hectares were recorded as equipped, infrastructure expansion continued steadily in the following decades, exceeding 0.5 million hectares in the mid-1950s and approaching 0.8 million hectares in 1965. Investment rhythm intensified subsequently, so that by 1975 the area reached nearly 2 million hectares, and in the early 1980s it exceeded 2.5 million hectares. The maximum level of development was reached at the end of the ninth decade, when total developments rose to over 3.2 million hectares.

After this peak period, data indicate a reduction in functional area. At the end of the 1990s, land under the administration of the National Agency for Land Reclamation totalled approximately 3.2 million hectares, with water evacuation carried out both by pumping and gravitational means, the two modalities having relatively similar shares. The system was served by a complex technical ensemble, including hundreds of developments, thousands of kilometres of canals and drains, pumping stations, as well as numerous auxiliary crossing and regulation constructions.

The long-term functionality of these works depended essentially on the operating regime and permanent monitoring of soil property evolution. Institutional transformations after 1990, however, modified the framework of use. The pronounced fragmentation of land associated with property restitution processes did not take into account the geometry of underground networks, many parcels being delimited without correlation to drain positions. In parallel, the lack of maintenance interventions led to accelerated infrastructure degradation. Numerous constructive elements were affected, including slope reinforcements, connections between sectors, and flow control points, which considerably reduced the operational capacity of systems.

Following this background, the comparative analysis of the years 1997, 2007, 2017, and the average of the 2020-2024 period allows capturing the recent trajectory of equipped areas and evaluating the extent to which previous investment legacy was maintained or, on the contrary, eroded over time.

The data synthesized in Table 2 show that, following the high levels recorded at the end of the previous century, infrastructure intended to combat excess moisture entered a process of slow but continuous contraction.

Table 2. Dynamics of land equipped with dewatering and drainage works at national level (ha)

No.	Land Use Category	Year						
		1997*	2007*		2017		2020-2024**Average	
		Absolute area (ha)	Absolute area (ha)	±Δ1997 vs 2007**	Absolute area (ha)	±Δ 1997 vs 2007**	Absolute area (ha)	±Δ1997 vs Average 2020-2024**
1	Total equipped area	3,198,803	3,152,484	-46,319	3,149,953	-48,850	3,146,514	-52,289
2	Equipped agricultural area	2,949,913	2,911,441	-38,472	2901207	-48,706	2,893,743.4	-56,169.6
3	Arable land	2,553,962	2,511,146	-42,816	2504153	-49,809	2,497,002.2	-56,959.8
4	Natural pastures	256,820	262,148	+5,328	259057	+2,237	258,890	+2,070
5	Natural hayfields	109,943	110,762	+819	111079	+1,136	110,933.2	+990.2
6	Vineyards and vine nurseries	15,676	147,56	-920	14677	-999	14,677	-999
7	Orchards and fruit nurseries	13,512	12,629	-883	12241	-1,271	12,241	-1,271
8	Equipped non-agricultural area	248,890	241,043	-7,847	248746	-144	252,770.6	+3,880.6

* http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table (15.12.2025)
** Own calculations

Reference to the base year 1997 shows a reduction of total area by over 46 thousand hectares by 2007, a trend confirmed by subsequent evolution, so that the difference compared to the 2020–2024 average exceeds 52 thousand hectares (Figure 2).

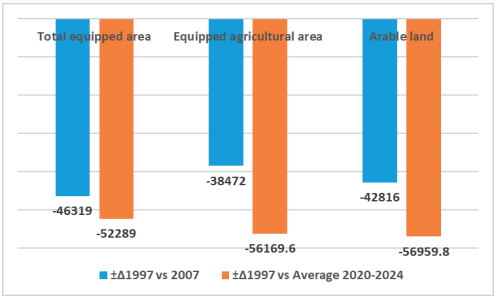


Figure 2. Dynamics of equipped areas – total, agricultural, and arable (ha; ±Δ compared to 1997)

The descending trajectory is also visible in the graphical representation of total, agricultural, and arable areas (Figure 3), where the negative slope is maintained throughout the analyzed interval.

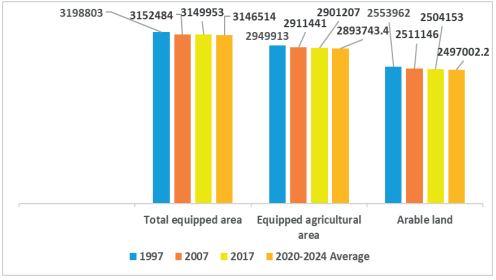


Figure 3. Dynamics of equipped areas – total, agricultural, and arable (ha)

The equipped agricultural area follows the same pattern, indicating that structural adjustments primarily targeted productive land. According to Table 2, the cumulative decrease between 1997 and the recent period exceeds 56 thousand hectares.

The largest contribution to the decline belongs to arable land. The initial reduction, of over 42 thousand hectares in the first decade, is followed by an additional decrease, so that at the level of the 2020-2024 average, total loss approaches 57 thousand hectares compared to the base year (Table 2). The higher intensity of withdrawal in the first part of the interval is clearly reflected in the dynamics presented in Figure 2.

In contrast to this trend, extensive uses show limited variations. Natural pastures mark an increase in the initial stage, followed by minor adjustments, but the final balance remains positive compared to 1997 (Figure 4).

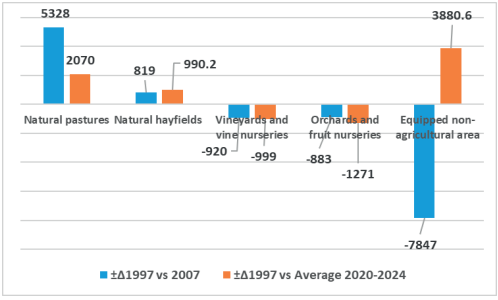


Figure 4. Dynamics of equipped areas – pastures, hayfields, vineyards, orchards, and non-agricultural land (ha; ±Δ compared to 1997)

Natural hayfields indicate similar stability, with small amplitude oscillations. These trends are detailed in Table 2 and graphically represented in Figure 5, where the curves associated with these categories exhibit a relatively stable, near-horizontal trajectory.

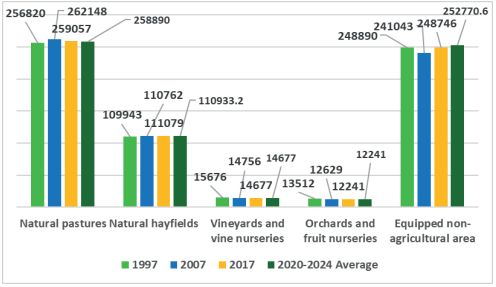


Figure 5. Dynamics of equipped areas – pastures, hayfields, vineyards, orchards, and non-agricultural land (ha)

For permanent plantations (vineyards and orchards), data reveal a constant reduction of equipped areas. Both vineyards and orchards register decreases of close to one thousand hectares compared to the initial level, a trend simultaneously confirmed by the tabular values and the representation in Figure 4.

In the case of non-agricultural areas, dynamics reveal an oscillatory course: after the decrease in the first stage, a recovery follows which, in

the recent interval, exceeds the level recorded in 1997. The interpretation of this evolution, however, requires caution, as it may reflect both the influence of administrative reclassifications and the effects of urban expansion and development of transport, industrial, and residential infrastructure, contexts in which the drainage function shifts from supporting agricultural use to protecting constructions and limiting flood risk or groundwater rise.

Overall, the correlation of numerical information with graphical representations outlines the image of a system undergoing gradual capacity decline, a phenomenon concentrated especially in the arable sector, where dependence on dewatering and drainage functioning is maximal.

Viewed as a whole, the data and graphical representations converge toward the same conclusion: the system has continuously lost area after 1997, with the main impact concentrated on arable land, where dependence on drainage functionality is highest. At the same time, the other categories showed either stability or limited variations, without altering the dominant structure of developments.

CONCLUSIONS

The long-term assessment of areas equipped with dewatering and drainage works highlights the emergence of a persistent trajectory of declining functionality of hydrotechnical infrastructure.

The identified trends exceed the level of simple statistical adjustments and indicate the manifestation of a cumulative decapitalization process, resulting from the interaction between financial constraints, institutional transformations, and continuous erosion of maintenance capacity.

In this framework, multiple technical evaluations show that after 1990 a major proportion of constructions related to canal networks evolved toward advanced states of degradation. The lack of systematic maintenance interventions and desilting operations led to the deterioration of slope protections, affecting crossing and connection zones, as well as reducing the efficiency of flow regulation and measurement structures. The direct consequence is the progressive restriction of effectively serviced areas and the reduction of overall system performance.

From a conceptual perspective, dewatering and drainage infrastructure must be understood as a determinant of the adaptive capacity of agroecosystems. As its functional area decreases, the ability of the agricultural system to buffer hydrological variability declines, and land users tend to adopt cautious strategies oriented toward risk limitation rather than production intensification.

The persistence of these processes favors the establishment of path-dependence mechanisms, in which each year of underinvestment amplifies the difficulty and costs of potential restoration. In the absence of coordinated interventions, vulnerability becomes a structural rather than conjunctural characteristic.

Looking toward the future, climate projections for Central and Eastern Europe indicate an increase in the frequency of hydrological extremes, with more pronounced alternations between intense precipitation and prolonged water deficit periods. In such a context, existing systems will be subjected simultaneously to the requirement of rapid evacuation of excess volumes and the necessity of conserving resources during drought intervals. For arable land, where development concentration is dominant, this variability may exceed the initial design parameters of infrastructure. Without technological modernization and adoption of flexible operating mechanisms, the efficiency of works risks declining, and exposure of agricultural production to hazard increasing.

At the same time, modification of hydric regimes has the potential to redraw the map of intervention needs, transforming areas considered today relatively stable into future investment priorities.

In the context of increasing climatic variability and the growing frequency of extreme hydrological events, the development of drainage and dewatering infrastructure should be directed toward:

- the systematic rehabilitation of existing networks and the modernization of pumping stations;

- the integration of drainage systems with water retention and reuse facilities;
- the updating of design parameters in accordance with emerging climate scenarios;
- the strengthening of the institutional framework and the provision of multiannual financing mechanisms;
- the implementation of digital water-level monitoring systems.

Drainage infrastructure can no longer be addressed solely as a water evacuation mechanism; rather, it must be integrated into an adaptive water resources management strategy, essential for maintaining agricultural productivity and reducing the vulnerability of agroecosystems.

By integrating statistical evidence with institutional and climatic interpretation, the study provides an analytical framework transferable to numerous regions confronted with aging infrastructure. The central message is clear: passivity does not preserve infrastructure but accelerates its functional decline, leading to more rapid deterioration.

REFERENCES

Baborowski, M., Rupp, H., Wendt-Potthoff, K., Tauchnitz, N., & Meissner, R. (2021). Factors affecting the spatial and temporal variability of metals in drainage water from arable fields. *Clean - Soil Air Water*, 49(6).

Balan, M., Nitu, O.A., & Popescu, C. (2024). The evolution of soil agrochemical properties, under the influence of mineral fertilisation and water erosion, on a natural grassland located at the Preajba Experimental Centre in the Gorj county. *Scientific Papers. Series A. Agronomy*, LXVII, 1, ISSN 2285-5785, 25-31.

Birkáš, M., Jug, D., Kisić, I., Kassai, KM, Tarnawa, Á. & Jolánkai, M. (2021). Water management in the soil-plant system – a challenge for the 21st century. *Acta Horticulturae et Regiotecturae*, 24, 16-19.

Blann, K. L., Anderson, J. L., Sands, G. R., & Vondracek, B. (2009). Effects of agricultural drainage on aquatic ecosystems: a review. *Critical reviews in environmental science and technology*, 39(11), 909-1001.

Bonea, D. (2020). Grain yield and drought tolerance indices of maize hybrids. *Notulae Scientia Biologicae*, 12(2), 376–386.

Corcheș, M.T. (2023), Land degradation and climate change. *Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering,* XII, Print ISSN 2285-6064, 68-73.

David, G., Țărău, D., Sandor, C., & Niță, L. (2018). Soil and climate factors that define land productivity in the lower plain of Banat. *International Multidisciplinary Scientific GeoConference: SGEM*, 18(3.2), 465–472.

De Wrachien, D., & Mambretti, S. (2012). Mathematical models in flood management: overview, laboratory tests and case study. In S. Mambretti (Ed.), *Flood Risk Assessment and Management*, Wit Press, 11-22.

Dollinger, J. (2016). *Analysis and modelling of pesticide transfer and retention in infiltration ditches on the farm according to different management strategies*. *HAL (Le Centre Pour La Communication Scientifique Directe).*

Ilie, L., Mihalache, M., Marin, D.I., Scăețeanu, G. (2012). Climatic conditions and evolution of soil profiles in Romania. *Annals of the University of Craiova-Agriculture, Montanology, Cadastre Series*, 42(2), 118–123.

de Wit, J. A., Ritsema, C. C., van Dam, J. J., van den Eertwegh, G. G., & Bartholomeus, R. R. (2022). Development of subsurface drainage systems: Discharge – retention – recharge*, Agricultural Water Management, 269, 107677.*

Kulshreshtha, S. & Elshorbagy, A. (2017). Current perspective on irrigation and drainage. *InTech eBooks*.

Lațo K.I., Lațo A., Nita D.L., Duma-Copcea A., & Corches M.T. (2022). Pedo-genetical factors implicated in soil degradation (lower Timis River basin area). *Scientific Papers. Series A. Agronomy*, LXV, 1, ISSN 2285-5785, 91-96.

Manik, S.M.N., Pengilley, G., Dean, G., Field, B.G., Shabala, S. & Zhou, M. (2019). Soil and crop management practices to minimise the impact of floods on crop productivity. *Frontiers in Plant Science*, 10, 140. Frontiers Media. https://doi.org/10.3389/fpls.2019.00140

Musat, I.B., Ciceoi, R., Musat, M., & Mihalache, M. (2021). Changes of physical properties in soils under traditional soil management in arable crops, in the southern part of Romania. *Scientific Papers. Series A. Agronomy*, LXIV, 1, ISSN 2285-5785, 112-118.

Nițu, O. A., Jerca, I. O., & Bălan, M. (2024). Drip irrigation efficiency in soybean cultivation in southeast Romania, a sustainable approach to water management. *Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering*, 13, 585-591.

Nițu O.A., Jerca I.O., Balan M., & Ivan E.Ș., (2025). Water use efficiency in irrigated agriculture in Romania: optimization strategies in the context of climate change. *Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering*. XIV, 705-710.

Popescu C., & Balan M., (2024). Evaluation through natural bonitation work of the soils in the zone of confluence of Dolj and Mehedinti Counties and the estimation of crop plant productions specific to the area. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*. 24, 2, ISSN 2284-7995, 809-816.

Ritzema, H. P. (2016). Drain for Gain: Managing salinity in irrigated lands - A review. *Agricultural Water Management,* 176, 18-28.

Skaggs, R. W., Fausey, N. R., & Evans, R. O. (2012). Drainage water management. Journal of soil and water conservation, 67(6), 167A-172A. Discharge–Retention–recharge. *Agricultural water management*, 269, 107677.

Ursu, A. (2014). Agrarian Economy and Rural Development - Realities and Prospects for Romania. *SSRN Electronic Journal.*

Yang, T., Jiang, J., He, Q., Shi, F., Jiang, H., Wu, H., He, C. (2025). Impact of drainage on peatland soil environments and greenhouse gas emissions in northeast China. *Scientific Reports*, 15(1), 8320.

https://www.anif.ro/ ANIF (2025) - Administratia Nationala a Imbunatatirilor Funciare

http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table

https://www.fao.org/home/en

https://www.madr.ro/

https://commission.europa.eu/law_en