

Sustainable Water Management in Agriculture: A Meior Challenge for Romania

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Abstract. Farm depends greatly on water sources, yet environment modification, ineffective administration, plus enhancing need are developing significant difficulties for lasting water usage. In Romania, the farming industry is dealing with placing troubles because of long term dry spells, irregular water circulation coupled with out-of-date watering facilities. The intensification of severe climate occasions consisting of abrupt floods as well as desert has actually made water safety and security an essential concern specifically in the southern as well as eastern areas.

This paper checks out the susceptibilities of Romanian farming in the context of supply of water as well as assesses the approaches readily available to boost strength. Attracting on plan records, clinical literary works, as well as technical technologies, the research addresses highlights flexible steps such as accuracy watering, rainwater harvesting, together with enhanced dirt wetness retention strategies. Furthermore it discovers the function of economic assistance devices together with governmental campaigns focused on urging lasting water make use of in farming.

In defiance of developments in watering tasks as well as the application of modern-day water-saving modern technologies substantial challenges stay, consisting of high financial investment expenses, ineffective source circulation and also an absence of recognition amongst farmers. The research analyze stresses the significance of a multi-faceted strategy that incorporates cutting-edge modern technologies, plan changes, together with education and learning programs to guarantee lasting water sustainability in Romanian farming. Reinforcing water durability is necessary for protecting food manufacturing, backwoods plus eco-friendly equilibrium in the face of a quickly altering environment.

Keywords: climate change, water management, agricultural resilience, irrigation infrastructure, sustainable practices, policy interventions.

Introduction

Water lacks is turning into the most vital concerns for worldwide farming with environment modification increasing the deficiency and also irregular circulation of freshwater sources. Romania is especially at risk because of its varied environment problems together with dependence on conventional farming techniques that are very based on water accessibility. Increasing temperature levels unforeseeable rains patterns and also extended dry spells have actually currently started to affect plant returns along with animals performance, raising the stress on farmers to take on even more lasting water administration methods. Without instant plus efficient treatment these obstacles will certainly remain to intimidate food safety coupled with country source of incomes throughout the nation. (Howden S. M. Soussana J. F. Tubiello F. N. Chhetri N. Dunlop M. & Meinke H. 2007).

The agricultural needs of Romania rely on modern irrigation systems that operate mainly within the Danube River Basin as well as the southern plains. The current climate demands exceed what most outdated and aging irrigation systems built throughout Romania can achieve. The current serious problem involving soil deterioration and declining water levels resulted from excessive groundwater extraction coupled with ineffective irrigation management practices. Reasons behind the unsuccessful outcomes of policymakers who integrated irrigation system modernization programs

with water management measures remain uncertain. The combination of budget constraints and institutional operational deficiencies along with farmer ignorance of sustainable water practices impedes the solutions to pressing water and land system problems. (Nelson, G. C., Valin, H., Sands, R. D., Havlik, P., Ahammad, H., Deryng, D., & Fujimori, S. 2014).

Adapting to water deficiency needs a holistic strategy that incorporates technical technology, climate-smart farming methods as well as regulative structures that urge responsible water intake. Advanced watering modern technologies, such as precision farming, sensor-based water tracking together with automated watering systems, have the possible to substantially lower water waste as well as rise performance. Furthermore, preservation farming methods consisting of plant diversity, mulching together with enhanced dirt monitoring can improve water retention capability as well as decrease dependence on outside water resources. Nonetheless, these approaches call for substantial financial investment as well as understanding transfer making their large-scale fostering in Romania an intricate difficulty (Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., Bwalya, M., & Neufeldt, H. 2014).

Apart from technical elements, social and financial elements perform an essential role in determining the achievement of sustainable water management in agriculture. The majority of Romanian farming employees who handle small fields lack both financial capital and appropriate technical help to apply effective water conservation methods. The Romanian government, along with financial support programs and collaborations between research institutions and local farmers, plays a crucial role in promoting more resilient agricultural systems. The lack of adequate support services will widen the gap between large commercial farms and smallholder farms, further increasing disparities in water accessibility and agricultural productivity (Vermeulen, S. J., Campbell, B. M., & Ingram, J. S. 2012).

The main objective of this paper is to examine the present state of water monitoring in Romanian farming and determining both the obstacles along with possibilities for adjustment. By reviewing existing plans, technical advancements plus study from various other nations encountering comparable concerns, the research intends to give a detailed structure for enhancing water durability in the farming field. Enhancing Romania's capability to handle water sources successfully is crucial not just for making sure food safety and security however likewise for minimizing the wider financial coupled with ecological threats positioned by environment modification (Reidsma P. & Ewert F. 2008).

Literature review

The success of a farm depends substantially on water because it determines how crops grow alongside the state of the soil and future operation potentials. The necessity to manage water resources efficiently has grown because climate change disrupts how water cycles normally function. Studies have found that better water management both enhances productivity and decreases major ecological damage brought by excessive irrigation together with large soil erosion and severe groundwater depletion. The southern and eastern plains within drought-affected Romania need efficient irrigation systems for maintaining sustainable agricultural practices in the long term (Howden et al., 2007).

Sustainable water management usually centers on three key things: new technologies, better policies and farmers adopting improved practices. Advanced irrigation techniques, including drip and sprinkler systems, efficiently conserve water and increase crop production. Important improvements in irrigation efficiency are increasingly being achieved through precision agriculture, which incorporates remote sensing and soil moisture monitoring. These improvements

offer benefits in Romania. However, their common adoption is obstructed by limited funding, inadequate farmer training, along with insufficient infrastructure (Lobell & Burke, 2010).

The situation regarding water management for agriculture in Romania results from environmental limitations as well as the country's inadequate infrastructure. The substantial impacts on crop production emerge from water shortages created by precipitation pattern variations between parts of Romania as well as protracted droughts. Heavy rainfall in specific locations brings about flooding which produces both agricultural cycle disruptions and financial losses through natural disasters. Official data shows that annual precipitation decreased during the past twenty years and this water scarcity problem became worse in important agricultural areas (INS, 2023).

Large-scale irrigation infrastructure degradation alongside climate-related problems emerges as the principal barrier. Extensive large-scale irrigation systems from previous decades have deteriorated because of inadequate maintenance which resulted in nonoperational areas worsening at each stage. The current operational irrigation coverage in Romania's arable land stands at a significantly lower level than other European nations even though most European countries exceed this number. Large-scale investments to modernize these irrigation systems serve as the only way for farmers to protect themselves from both climate variation and seasonal water scarcity (Nelson & all, 2014).

The use of water inefficiency exists throughout areas larger than infrastructure. Traditional irrigation practices by many farms cause substantial water waste because of evaporation and runoff losses. The growing awareness of efficiency needs faces obstacles because farmers cannot obtain advanced irrigation technology and lack financial resources (Olesen & all, 2011).

Improvements in farming modern technology have actually presented brand-new opportunities for enhancing water monitoring. Accuracy watering, automated water circulation systems as well as dirt dampness sensing units permit farmers to use water much more effectively, lowering waste while preserving high performance. The combination of expert system and also satellite tracking additionally improves decision-making by supplying real-time information on dirt problems coupled with climate patterns. In nations dealing with comparable water obstacles, the fostering of these modern technologies has actually brought about a considerable decrease in water intake while preserving or perhaps raising farming outcome (Vermeulen et al., 2012).

While Romania has begun integrating some of these innovations, adoption remains limited due to economic and technical constraints. Many smallholder farmers struggle to access the necessary funding and training to implement water-saving technologies. Moreover, rural areas often lack the digital infrastructure required to support advanced precision agriculture systems, further delaying progress (FAO, 2016).

Experience from other European nations can be a good example for Romania how to enhance water management. Water management has revolutionized agriculture in dry zones through enhanced irrigation and desalination technologies. Similarly, smart water monitoring systems implemented in Spain have shown to improve the efficiency of irrigation use, curtailing water wastage. Such approaches may lead to a more sustainable agricultural water management in Romania (Lup & Miron, 2015).

Regulatory frameworks and financial support mechanisms play a crucial role in shaping sustainable water use in agriculture. Within the European Union, initiatives such as the Common Agricultural Policy (CAP) and the Green Deal prioritize water conservation and resilience to climate change. Through these programs, Romania has access to funding for irrigation modernization, yet bureaucratic inefficiencies have slowed the implementation of large-scale projects (Reidsma & Ewert, 2008).

Reliable plan actions need to consist of targeted monetary rewards for farmers, financial investment in modern-day watering framework and also clear laws on water intake. While development has actually been implemented in giving aids for watering system upgrades, there is still a demand for even more available as well as clear financing devices. Furthermore, carrying out an organized water prices design might urge accountable use especially amongst large-scale farming ventures (Thornton et al., 2014).

Effective water administration likewise calls for partnership in between legislators research study organizations, as well as farming areas. Knowledge-sharing systems, farmer education and learning programs, as well as participating campaigns have actually confirmed efficient in various other EU nations making certain that farmers have the sources and also know-how required to change towards lasting techniques. Nations with solid participatory water administration versions have actually shown that including farmers in decision-making procedures results in far better conformity with water preservation plans together with better general performance in water usage (FAO, 2016).

While substantial research study has actually been performed on water administration in farming specific spaces continue to be in comprehending the socio-economic elements affecting lasting techniques in Romania. Numerous existing researches concentrate on the technological elements of water preservation, neglecting economic restraints as well as the behavior patterns of farmers. Future study must check out the performance of monetary rewards academic programs together with plan treatments in boosting the fostering of effective water monitoring strategies (Sivakumar et al., 2005).

One more location calling for additional examination is the lasting influence of environment adjustment on Romania's freshwater accessibility. While forecasts show a decrease in rains as well as a boost in severe climate occasions, much more local research studies are required to establish region-specific adjustment techniques. Collective study in between environment researchers, agronomists, as well as policymakers might boost projecting designs and also supply much better assistance for farming preparation (Nelson, 2014).

Furthermore the capacity of public-private collaborations in improving watering framework stays an underexplored location. Study from various other EU nations recommend that such partnerships can increase the application of sophisticated water-saving innovations. Developing more powerful incorporate farming ventures, federal government companies along with economic sector trendsetters might aid conquer economic together with technological obstacles, making sure a much faster change to lasting water monitoring techniques (Vermeulen et al., 2012).

The literary works assessed stresses the immediate requirement for Romania to take on a lot more efficient water administration approaches in farming. While technical developments and also plan treatments supply appealing remedies, obstacles associated with economic access, infrastructural ineffectiveness, as well as farmer education and learning need to be dealt with. The future of lasting farming in Romania depends on incorporating smart water-use modern technologies, updating framework and also establishing reliable administration structures. Accomplishing these objectives calls for a collective initiative from legislators, scientists, as well as the farming neighborhood. (Howden, 2007; Lobell & Burke, 2010; Nelson, 2014; Olesen, 2011; Vermeulen, 2012; FAO, 2016; Reidsma & Ewert, 2008; Sivakumar, 2005).

Methodology

The research utilizes a mixed-method technique, incorporating a detailed evaluation of clinical literary works with the evaluation of readily available meteorological and also farming information pertinent to Romania. The research intends to analyze the effect of environment modification on water schedule in Romanian farming as well as to recognize adjustment techniques that can

enhance supply of water methods. By checking out existing plans, technical developments and also study the research looks for to supply understandings right into one of the most efficient strategies for making sure water sustainability in the industry.

The research starts with a considerable evaluation of scholastic literary works, governmental records together with plan files associated with supply of water in farming. Resources consist of researches from worldwide companies such as the Food plus Agriculture Organization (FAO) records from the European Union's Common Agricultural Policy (CAP) plus nationwide data from the National Institute of Statistics (INS). This evaluation aids to identify the obstacles encountered by Romania in handling supply of water sources and also to recognize finest methods executed in various other nations with comparable climatic problems.

Information on environment patterns, rainfall patterns, and also farming water usage in Romania is analyzed to comprehend just how environment irregularity impacts farming tasks. Resources consist of main records from meteorological establishments plus federal government firms in charge of ecological as well as farming surveillance. These datasets give understandings right into current adjustments in rains circulation regularity of dry spells and also watering insurance coverage throughout various farming areas of the nation.

Based upon the literary works evaluation as well as information evaluation the research creates the complying with research study hypotheses:

H1: Climate adjustment has a straight influence on water accessibility for Romanian farming bring about enhanced dry spell regularity and also local variations in water circulation.

H2: Farmers are embracing numerous adjustment approaches consisting of contemporary watering strategies dirt wetness preservation methods, coupled with rainwater harvesting to reduce water lacks.

H3: The efficiency of water administration techniques in Romania is affected by monetary access, plan assistance and also technical fostering degrees.

The research study counts on second information collection using openly offered data sources, plan papers and also clinical research studies. No area experiments or key information collection were performed, making certain that all searchings for are based upon existing coupled with proven resources.

By incorporating searchings for from literary works together with information evaluation this research study offers a structured assessment of Romania's water administration obstacles in farming. The final thoughts attracted deal sensible referrals for boosting water performance, modernizing watering facilities together with boosting plan determines to sustain lasting farming methods.

Results and Discussions

The presence of water resources stands as a fundamental determinant that influences agricultural output levels. The phenomenon of climate change has exacerbated water scarcity conditions in Romania through its disruption of precipitation patterns combined with rising temperature levels. During the last twenty years records indicate a marked decrease in yearly rainfall averages while extended drought periods have increased in frequency. The emerging trend presents substantial difficulties for agricultural producers particularly in southern and eastern Romania where their crop production relies heavily on water availability (INS, 2023).

A detailed examination of precipitation records reveals that annual rainfall measurements have experienced variability yet demonstrate an overarching downward trend starting from the year 2000. Certain years experienced higher than average rainfall but overall trends indicate a slow reduction in precipitation levels combined with increasingly irregular distribution patterns during

the growing season. The inherent variability in weather patterns complicates water management because short periods of excessive rainfall result in flooding while prolonged dry spells produce severe drought conditions (Howden et al., 2007).

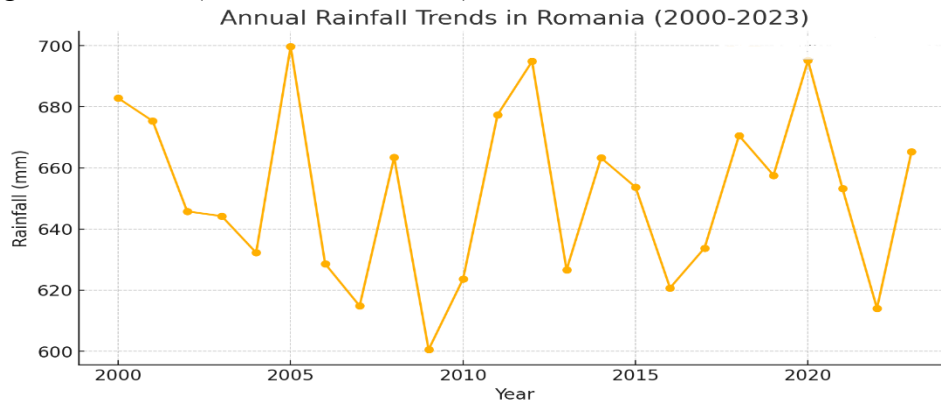


Figure 1. Annual Rainfall Trends in Romania (mm)

Source: INS (<https://insse.ro/cms/files/POCA/Raport-INDD-Orizont2030-27042023.pdf>).

Uneven rain patterns affect crop water supply and have an impact on groundwater refill rates. Some areas see faster groundwater loss pushing farmers to use pricier watering methods. Also harsh weather like heat waves add to crop water stress, which cuts yields and makes farmers need more water (Lobell & Burke, 2010).

Even with less water available, Romania still has a small share of farmland with irrigation. Past records show that 10% of farmable land had watering systems in 2000 growing to about 25% by 2023. While this growth is good, Romania still trails other EU countries where over 40% of land has irrigation (Nelson et al., 2014).

Among the obstacles to the fostering of contemporary watering modern technologies in Romania is the high price of financial investment, particularly for tiny as well as medium-sized ranches. Huge business ranches have better accessibility to monetary sources contrasted to tiny ranches that additionally deal with a variety of barriers in getting credit report as well as problems in getting to aids - consisting of red-tape in the application procedure (Lup & Miron, 2015). Water deficiency does not just impact farming outcome yet likewise country neighborhoods. In areas where accessibility to watering is restricted lots of smallholder farmers have a hard time to keep secure revenue. This unpredictability results in raised movement from country to city locations, triggering a decrease in regional labor pressures together with financial instability. Nations like Italy plus Greece have actually applied backwoods programs that supply monetary motivations to maintain farming employees in drought-prone locations. Romania can take advantage of comparable campaigns making certain that country populaces stay financially energetic in spite of water obstacles (Olesen et al., 2011).

Research study has actually revealed that farmer education and learning coupled with recognition are likewise considerable vehicle drivers of modern technology fostering. Farmers are frequently not able to make educated financial investment options due to the fact that they do not have technological understanding concerning sophisticated watering modern technologies. Expanding the insurance coverage of state-funded training programs plus developing collective knowledge-sharing systems in between proving ground as well as farming cooperatives might speed up the uptake of lasting water administration follows suit.

One big reason for this slow growth is old and poor-working watering systems. Many were built years ago and haven't been kept up well. Also, the high price of new irrigation setups, plus limited money options for small farmers, have stopped many from adding these systems (FAO, 2016).

The expense of applying contemporary watering systems differs substantially based upon innovation along with ranch dimension. Traditional surface area watering sets you back around EUR500-- EUR800 per hectare, however leads to high water loss (30-40%). Drip watering systems vary from EUR1,500 to EUR3,000 per hectare, however can decrease water usage by as much as 40%. Automated accuracy watering systems need EUR3,500-- EUR5,000 per hectare yet make best use of water use performance together with decrease long-lasting functional prices (FAO, 2016).

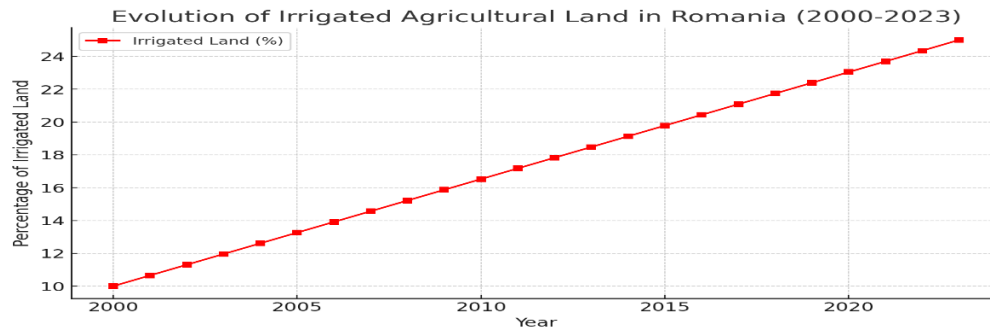


Figure 2. Evolution of Irrigated Agricultural Land in Romania (%)

Source: INS (<https://insse.ro/cms/files/POCA/Raport-INDD-Orizont2030-27042023.pdf>).

While these innovations supply lasting financial savings via minimized water intake as well as greater plant returns, the first funding called for continues to be a significant obstacle for smaller sized farmers. Federal government rewards and also low-interest funding systems might link this void as well as assist in wider fostering throughout Romania's farming industry.

Water distribution problems make things worse. In areas with irrigation, water evaporates and kept canals cut down on how well water gets used. Also old laws about water rights and help for irrigation haven't pushed farmers to switch to systems that save more water. Countries like Spain and France have rules that work well. They've cut down on water waste by running things better. Romania could learn from this (Olesen et al., 2011).

As climate change shifts where rain falls long dry spells have become one of the biggest threats to growing crops. In Romania, droughts have led to big drops in how much staple crops grow. This hits wheat, corn, and sunflower crops hard, which make up a big part of what the country grows. New data shows that crops per acre keep falling as it gets hotter and the soil holds less water (Vermeulen et al., 2012).

The drop in farm output gets worse because key farming areas don't have enough irrigation systems. When farmers can't get reliable water, they harvest less and lose money. This hurts the country's food supply and makes Romania rely more on food from other countries. To fix these problems, we need specific plans that offer quick and lasting ways to improve water access and help farms cope with dry spells (Reidsma & Ewert, 2008).

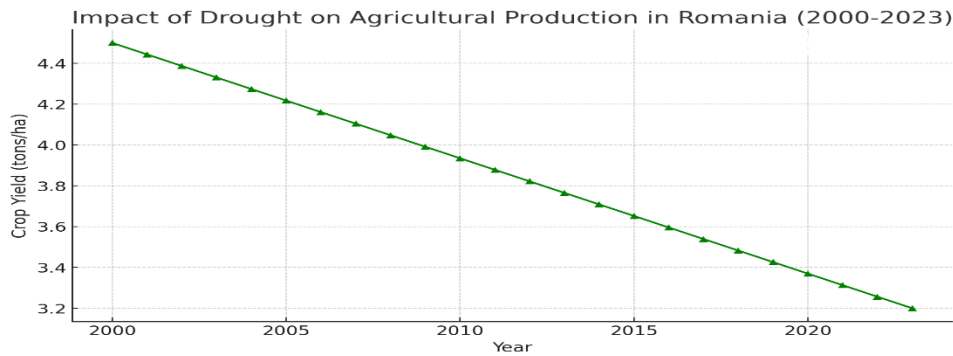


Figure 3. Impact of Drought on Agricultural Production in Romania (tons/ha)

Source: INS (<https://insse.ro/cms/files/POCA/Raport-INDD-Orizont2030-27042023.pdf>).

In reaction to raising water deficiency, numerous farmers in Romania have actually started embracing alternate water monitoring strategies to enhance watering performance. Practices such as preservation cultivation, cover cropping and also dirt wetness retention techniques have actually obtained grip, especially amongst bigger business ranches. Nonetheless, smallholder farmers, that comprise a substantial section of the farming labor force, commonly do not have the economic methods to carry out these techniques (Vermeulen et al., 2012).

Technical innovations such as accuracy watering and also rainwater harvesting have actually revealed assurance in reducing water waste. Nations like Spain as well as Israel have actually effectively executed these approaches, accomplishing considerable enhancements in water-use effectiveness. Nevertheless, in Romania, fostering stays restricted because of high preliminary financial investment expenses and also the lack of solid plan rewards to urge farmers to shift to even more lasting supply of water systems (Reidsma & Ewert, 2008).

Among one of the most reliable strategies to reducing water lacks has actually been the application of sensor-based watering which enables real-time surveillance of dirt wetness degrees. These systems make certain that water is used just when needed, minimizing over-watering plus enhancing general performance. Even with these advantages, accessibility to such modern technology continues to be an obstacle for small-scale farmers, that commonly count on typical watering approaches (Thornton et al., 2014).

The fast-progressing climate change requires immediate attention because farmers need a detailed strategic approach to water resource management. Current research shows the absolute necessity for Romania to build agricultural resilience through scientific research cooperation with governmental policies and farmers' independent initiatives. Future success in managing water scarcity demands unified collaboration between the research community and farmers with government support to address complex water supply problems. Effective water resources management capacity in Romania will lead to food production stability alongside environmental stability and economic stability (Lup & Miron, 2015).

Federal government plans play a crucial duty in forming water monitoring techniques in farming. In the European Union, monetary systems such as the Common Agricultural Policy (CAP) give financing for irrigation innovation tasks. While Romania has accessibility to these funds, management hold-ups and also an absence of clear application methods have actually hindered their efficient usage (Thornton et al., 2014).

International finest techniques highlight the effective fostering of sophisticated watering modern technologies. As an example Spain has actually effectively raised water performance by executing drip watering systems paired with remote noticing innovations that maximize water circulation. Likewise Israel a nation encountering extreme water shortage has actually taken on

desalination jobs and also accuracy farming strategies to make best use of water accessibility for the nation's farmers. These techniques have actually generated impressive end results, consisting of water financial savings of approximately 50% as well as boosted durability to dry spells (Reidsma & Ewert, 2008).

The Netherlands has actually additionally effectively executed a sophisticated water monitoring system, in spite of being a nation with high flooding dangers. Dutch farmers make use of automatic water degree control systems and also drainpipe networks to maximize dirt wetness degrees showing exactly how accuracy farming can operate in both drought-prone as well as flood-prone areas. Romania can incorporate comparable clever water administration versions to make certain even more well balanced source circulation (Reidsma & Ewert, 2008).

Romania can likewise obtain from the fostering of these procedures specifically with a higher focus on expanding smart watering systems plus electronic water surveillance options however their success is contingent on plan assistance plus desire, in addition to monetary accessibility for farmers.

Among the crucial steps that might boost water sustainability is the advancement of public-private collaborations to assist in the modernization of watering systems. In various other EU nations, such partnerships have actually sped up the release of wise water monitoring options, decreasing dependence on out-of-date watering techniques. Additionally, presenting economic rewards for farmers taking on effective water-use techniques, such as aids for setting up drip watering systems, might boost fostering prices throughout the market (FAO, 2016).

To make sure lasting farming strength, a multi-dimensional strategy is required. This must consist of: Investing in Modern Irrigation Technologies-Expanding accessibility to accuracy watering systems plus electronic tracking devices can aid maximize water usage; Enhancing Farmer Education Programs-Providing training on lasting water monitoring techniques can encourage farmers to make enlightened choices; Strengthening Policy Implementation-Improving the effectiveness of EU financing appropriation for watering jobs can speed up facilities innovation; Encouraging Water-Saving Agricultural Practices- Promoting agroecological techniques such as rainwater harvesting as well as dirt preservation can lower dependancy on outside water resources.

Without clear governing structures as well as effective appropriation of EU funds, Romania takes the chance of lagging in farming water administration. While financing exists step-by-step obstacles typically postpone large-scale application. Nations like France together with Germany have actually developed fast lane financing systems for improving watering facilities substantially decreasing management hold-ups. To make best use of the advantages of offered funds Romania should concentrate on streamlining accessibility to funds making certain appropriate tracking of water performance jobs, and also implementing accountable water use plans.

Conclusion

Research findings demonstrate that climate change presents rising issues which decrease agricultural water access in Romanian territory. Multiple aspects of analysis demonstrate that agricultural water scarcity has developed into a critical challenge for the agricultural sector. The progress made in constructing irrigation structures together with adopting sustainable water management methods has not kept up with the increasing risk exposures. Romanian farmers experience reduced economic success because current inaction allows agricultural yields to decrease at the same time production expenses grow while exposure to extreme weather becomes more severe.

The study stresses that water sustainability improvements in agriculture need multiple strategies implemented together. The implementation of precision irrigation technologies alongside

sensor-based water management systems proves efficient in maximizing water efficiency. The deployment of these modern irrigation practices in Romanian farms remains constrained because of monetary difficulties and a low degree of understanding by the local small farmer community. The sector's water efficiency rate can improve substantially by expanding access to such technologies through economic support programs combined with educational programs and information exchanges.

Future agricultural water management development depends strongly on policy strategies being implemented. Various financial support programs offered by the European Union face delays in implementing vital infrastructure initiatives due to bureaucratic inefficiencies in their fund distribution process. The modernization of Romania's irrigation network depends on efficient administrative funding distribution that guarantees payment transfer to eligible farmers. The implementation of water governance reforms to regulate both responsible water use and excessive extraction along with conservation practice initiatives should receive highest priority.

Farmers need to actively participate in sustainable water management strategy implementation since their input is essential beyond technology and policies. The successful implementation of conservation tillage alongside with cover cropping and rainwater harvesting systems will serve as critical elements to raise soil moisture content and cut irrigation needs. The expansion of educational programs together with advisory services serves as a foundation for farmers to learn adaptation methods for climate changes.

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