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Szarvas, Hungary

Editors: Zoltán Futó, Károly Bodnár

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COPING WITH WATER SCARCITY FOR RICE PRODUCTION IN THE PHILIPPINES: ADVANCEMENT AND CHALLENGES IN RICE R&D

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ABSTRACT

The greater demand to produce more rice to cope with the increasing population in the Philippines has continuously put more pressure on growing rice with less resource input. Irrigation water, for example, is one of the limited resources in the country's agriculture sector owing to many challenges such as degrading watersheds, competing demands, and inefficient water management. The problems are also aggravated by the absence of an effective and real-time water-use monitoring system and unequal distribution of irrigation water within the basin. Thus, in response to the vision of a rice-secure Philippines, the Philippine Rice Research Institute is continuously developing and promoting water management technologies and practices for rice production to contribute to rice security amidst water scarcity and climate change challenges. This paper discusses the research and development (R&D) interventions (completed and ongoing) to address water scarcity problems and the dwindling effect of climate change on rice production. Among the R&D interventions to adapt to water scarcity and mitigate climate change are technologies and practices to reduce water requirement during land preparation and crop growth without yield loss; micro-irrigation such as drip irrigation and sprinkler irrigation in aerobic rice cultivation; improve operational irrigation efficiency using internet-of-things tools for a data-driven irrigation advisory; the use of a renewable source of energy for pumping water, and continuous promotion of best water management practices for rice production. The continuous R&D on water management for rice production focused on increasing water productivity and farmers' productivity and income and reducing the carbon footprints in rice.

Keywords: food security, water shortage, water scarcity, water management, R&D

INTRODUCTION

Rice is an important staple food in the Philippines, where the per capita consumption averaged 110 kg/person/year (PSA 2017). It is also a significant source of income where rice production is valued at ~6 billion U.S. dollars (Bersales 2016). The area planted for rice accounted for 30% of the total agricultural area in the country (Dawe 2003). The rice area harvested in 2021 was 4.80 Million ha, of which the irrigated farms shared three-fourths of the total rice production (PSA 2022). The rest comes from non-irrigated covering the rainfed and upland areas, where rainfall is the only source of irrigation. A typical irrigated rice is entirely dependent on irrigation during the dry season and supplemental irrigation during the wet season. It is usually grown under flooded conditions where irrigation water plays a crucial role from land preparation to crop growth. The flooding condition is at least 80% of the crop's duration, resulting in 2–3 times more water requirement than other irrigated crops (Bouman et al. 2007).

However, one of the issues confronting rice production in the country is water scarcity. Water scarcity could be defined from the views of physical or economic (Bond et al. 2019). Physical water scarcity describes the insufficiency of irrigation water to sustain crop production and or scarcity of freshwater availability in surface and groundwater bodies (Liu et al. 2017). It could also mean economic, which is the lack of socio-economic and institutional capacity that limits societal ability to use the renewable freshwater resources that are physically available (Huang et al. 2021). Both the physical and economic water scarcity confronts rice production in the Philippines. For example, the most common water supply problem in the national and communal irrigation system is water shortage during the dry season caused by less dependable small rivers and creeks and springs and runoff (Clemente et al. 2021). This condition is compounded by environmental problems such as denuded watersheds and the inability to control sedimentation resulting in reduced quantity and quality of water (Luyun and Elazegui 2021; Clemente et al. 2021). The problems are also aggravated by the absence of an effective and real-time water-use monitoring system and unequal distribution of irrigation water in the large-scale irrigation system (Regalado et al. 2019).

Moreover, the weak policy enforcement on canal maintenance and low water use efficiency at the field level exacerbates the water-scarce condition (Luyun and Elazegui 2021).

Furthermore, with a growing population projected to increase by 142 million by 2045 (PSA 2014), there is more pressure on producing rice to cope with the greater demands for food and competition from other water users (i.e., industry, domestic). Thus, within the context of rice production, we discuss the water management technologies and practices developed and promoted in the Philippines and the ways forward of the water-related R&D in rice production in contributing to rice security amidst the challenges of water scarcity and changing climate.

WATER RESOURCES AND MANAGEMENT CHALLENGES FOR RICE PRODUCTION

Agriculture's water use accounts for more than 80% share of the total water use in the country. A large percentage of water use is always associated with rice production, traditionally grown in bunded fields that are continuously flooded from land preparation to before harvest. Due to the saturated nature of rice, it has a water balance different from other cereal crops (Figure 1). The water balance includes the inflows by irrigation, rainfall, and capillary rise; and the outflows by transpiration, evaporation, overbund flow, seepage, and percolation (Bouman et al. 2007). The primary source of irrigation comes from gravity systems and shallow and deep wells. However, about 60% of the actual water input is estimated to be lost from the unbeneficial outflows, such as during the conveyance and crop growth.

Inocencio et al. (2013) suggested two issues facing agricultural development in the Philippines. First, how to increase productivity despite water scarcity, and second, how to respond to climate change. The causes of water scarcity are diverse and location-specific (Bouman et al. 2007). They include inefficient water management, declining water quality, falling groundwater tables, denuded watersheds, and increasing demands due to the growing population. Moreover, significant variations in the spatial and temporal distributions of rainfall and streamflow place a heavy demand for irrigation. For example, the most common water supply problem during the dry season is water shortage.

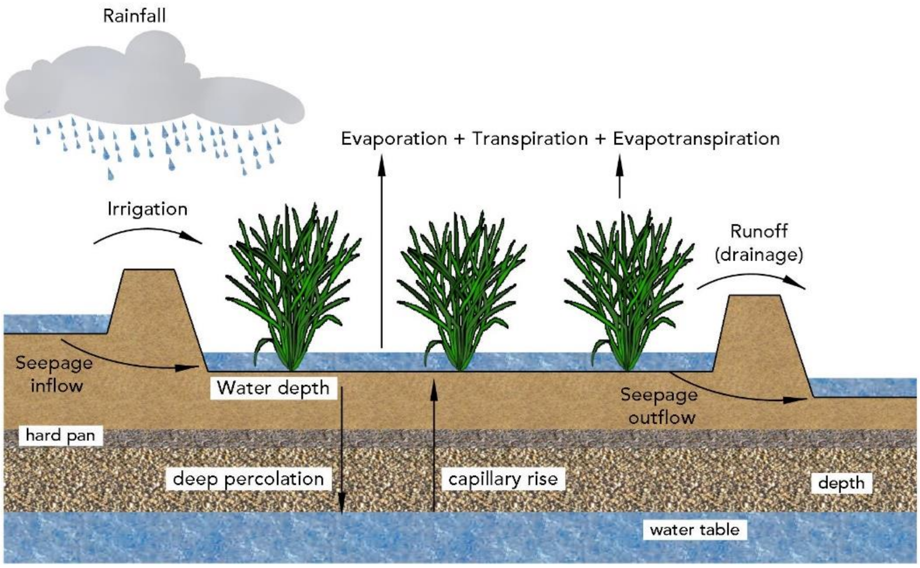

Figure 1. Field water balance in lowland rice (Adapted from Bouman et al. 2007)

This is manifested in the difference between the firmed-up service area and the actual irrigated area during the dry season (Clemente et al. 2021). In addition, the problems with siltation that decrease the available water in the irrigation system and increase the canal's efficiency losses also excarberates the water shortage.

There is also increasing pressure to transfer water from agricultural to domestic and industrial use. For example, water allocation and prioritization of domestic water supply toward the Manila area over the irrigation water supply in Bulacan has been the situation in the Angat Reservoir in recent years (Tabios 2018). Also, groundwater had decreased by 5.3 percent from 1988 to 2001, primarily attributed to the rising demand from the industrial and household sectors (NSCB 2003). Therefore, when confronted with insufficient irrigation supply, the majority of the farmers must rely on water-saving techniques to cope with water scarcity.

R&D INTERVENTION

Smallholder farmers dominate the irrigated rice cultivation in the country. Given the limited budget allocation for research, the Philippine Rice Research Institute, the national lead agency for rice and rice-based farming systems, set priorities on developing and promoting water management technologies that directly benefit rice farmers. The technologies and practices developed aim to address site-specific problems related to water depending on the hydrological and socio-economic environment of where the rice grows. Research programs on the water are integrated as a discipline-based and specialized R&D project embedded as a component of a larger program or a stand-alone project to address water scarcity problems, increase water productivity and efficiency, mitigate and adapt to climate change, and improve the operational efficiency of irrigation systems at the macro-scale.

The country's water-saving techniques developed and promoted are generally built on existing knowledge and fine-tuned to suit local field conditions. These are categorized to address water management in the different stages of rice production, as shown in Figure 1.

Land Preparation	Crop Establishment	Crop-Growth
• Dry land Preparation • Land leveling • Shallow tillage • Shortening the land preparation time	• Dry seeding • Wet seeding • Community seed-bed	• AWD • Drip irrigation • Sprinkler irrigation • Saturated soil culture • Aerobic rice • Mulching • Mid-season drainage

Figure 2. Water-saving technologies recommended at field-level

WATER MANAGEMENT DURING LAND PREPARATION

Wetland preparation is considered the usual practice in irrigated rice that requires adequate water during field operations. It involves land soaking and a series of tillage operations at saturation or in flooded condition for several days. However, due to the unbeneficial loss of water from percolation and evaporation during land soaking, several water-saving techniques have been recommended to reduce the water use at this initial stage of rice production. This involves tillage operations and processes that do not require much water in preparing the land.

a. Dryland preparation involves tilling the soil unflooded and typically involves dry plowing and leveling, similar to wetland preparation but with no standing water.

b. A well-leveled field promotes uniform distribution of water and nutrients in the field. In the PalayCheck System® for irrigated rice, the assessment to achieve a well-leveled area highlights the importance of no high and low soil spots after leveling. In addition, the recommended field water depth should not go beyond 5 cm water.

Recently, laser land leveling was promoted to achieve flat fields for planting. It is more reliable than visual judgment in leveling the area because of the precise and accurate leveling aided by a laser-equipped drag bucket. The introduction of laser-leveling in the fields was a collaborative project of IRRI and PhilRice through field demonstrations, training, and adoptive trials complemented by mechanical transplanting.

Shortening the land preparation time minimizes the turnaround time of multiple tillage operations. For example, the number of days for the interval between field operations (e.g., first harrowing and second harrowing) can be reduced to avoid idle periods during land soaking to avoid evaporation and percolation losses. A previous study showed that shortening the conventional wetland preparation period (i.e., 21 days) to 14 d is optimum to save water use while less weed density than seven days (Pascual et al. 2019). Similarly, minimizing the turnaround time between land soaking for wetland preparation and transplanting reduces the unproductive water loss (i.e., percolation and evaporation) from keeping the soil flooded or saturated.

WATER MANAGEMENT IN CROP ESTABLISHMENT

Direct seeding enables the crop to grow immediately without seedbed preparation requiring additional irrigation water input. It also increases rainfall's effective use and reduces supplemental irrigation during crop growth (Bouman et al. 2007). Direct wet and direct dry seeding are alternative options with less water input than transplanting. Dry seeding will be effective only in relatively clayey and impermeable soils that don't need

Also, community seedbeds are encouraged to ensure efficient water use during seedling growth. This also promotes synchronous planting and avoids overlapping incidences of insects and disease populations, preventing yield loss (PhilRice 2020).

WATER MANAGEMENT DURING CROP GROWTH

Saving water input during crop growth aims to reduce evaporation, percolation, and seepage of unproductive outflows. Typically, farmers try to maintain a high depth of water to control weeds. However, this practice leads to many unproductive outflows resulting in a field water use of around 1,300 mm or more (Bouman et al. 2007). However, irrigation water use can be reduced using water savings techniques, as shown in Table 1.

a. *Alternate Wetting and Drying Technique*

The AWD involves intermittent irrigation that allows the soil to dry based on a safe threshold level for irrigation before flooding the field up to 5 cm water depth above the soil surface. This practice was introduced in the Philippines in 2001 through participatory adaptive research in collaboration with the International Rice Research Institute (Lampayan et al. 2015). AWD is a complete departure from continuously flooding the field, saving up to 35% of irrigation water. The practical implementation of AWD promotes observation well or a perforated field water tube installed 15 cm below the soil surface to guide farmers on when to irrigate their fields (Bouman et al. 2007). Most studies conducted in the Philippines showed AWD did not reduce grain yield (Pascual et al. 2020; Lampayan et al. 2015; Lampayan et al. 2003) and saved 15 to 30% water use (Lampayan et al., 2003). At the field level, especially those using pump irrigation, farmers successfully adopted AWD because of the direct benefits of saving fuel (Pascual et al. 2021). Due to the promising result of AWD as a water-saving technique, there were two policy supports issued to promote safe AWD in the Philippines, i.e., Department of Agriculture-Administrative Order 25-2009 and National Irrigation Administration Memorandum Circular 36. However, the adoption of AWD in a large-scale irrigation system has been low and slow due to various factors such as water governance, biophysical landscapes, and socio-economic factors in rice farming (Enriquez et al. 2021; Pascual et al. 2021).

b. *Drip-irrigated aerobic rice*

Aerobic rice' was developed in which rice is grown in non-puddled and non-saturated soil, just like an upland crop (Bouman et al. 2005). The target environments for aerobic rice are irrigated lowlands with water shortage and favorable uplands with access to supplementary irrigation (Belder et al. 2005). The irrigation method can be flush or furrow irrigation and sprinklers to keep the soil wet but not flooded or saturated (Bouman et al. 2005). Low yields usually characterize aerobic rice in adverse environments where rainfall is low, and irrigation is unavailable. In addition, weed pressure in aerobic rice requires high input to produce a relatively good yield (Bouman 2008). IRRI collaborated with PhilRice to research the appropriate crop-water-nutrient management recommendations for aerobic rice in 2001 under the project Development of a System for Temperate and Tropical Aerobic Rice or

STAR (Templeton & Bayot, 2011). While farmers commonly used surface irrigation or flash flooding as an irrigation method, drip *irrigation was introduced to improve water productivity in rainfed areas in irrigated rice with insufficient water supply. The DA-Bureau of Agricultural Research funded the project with PhilRice as the lead implementer. The main objective was to develop a p*ackage of technologies for drip-irrigated aerobic rice that features the use of an optimally-laid out drip irrigation system; best options for managing weeds, as well as water and nutrients (fertigation); and complementing technologies for tapping water in challenging terrains to make it readily available for use.

Furthermore, before drip-irrigated aerobic rice, a gravity-type low-cost drip irrigation system (LDIS) was developed in 2009 for rice-based high-value crop production in upland areas and with the integration of fertigation (Ganotisi, 2009; Ganotosi and Galera, 2011). LDIS highlighted the parts and components of a drip system made of locally available materials to reduce the cost of commercially available drip irrigation.

c. Sprinkler Irrigation

A sprinkler irrigation system in aerobic rice is relatively new in the Philippines. The research focused on developing a custom-designed sprinkler irrigation system for smallholder farmers with a target area of 2500 m^2 in one setting. The system was designed so that the sprinkler assembly can be moved from one location to another to reduce the cost of having many sprinklers with an overlapping water distribution pattern (Remocal et al., 2020). The water pump and water delivery assembly of the customized sprinkler were built with engine-driven centrifugal pumps and hose and fittings commonly used by farmers. Compared with the conventional practice of surface flooding, The water use of the sprinkler was significantly lower by 59%, while water productivity was recorded at 0.90 kg m-3 (Remocal et al. 2020).

d. <u>Cappilarigation</u>

Due to the high cost of commercially-available drip irrigation, its adoption by smallholder farmers constrains them from adopting the technology. This led to the development of cappilarigation in 2015 using the principle of drip irrigation and capillary wicks (Sawey and Orge 2019). The cappillarigation system uses locally available capillary wicks to dispense scarce water frugally. It is a do-it-yourself technique intended for rice-based production to cope primarily with extreme drought. The material cost of the capillarigation system is lower by up to 80% compared to a commercially-available drip irrigation system (Orge and Sawey 2019).

Table 1. Water use and water savings of different water management techniques

Irrigation method	Water use, mm	Water savings, %	Source
Aerobic rice,	795	50.0	Bouman et al. 2005*
Flooded	1600		
AWD	584	48.0	Pascual et al. 2019
Continuously flooding	1123		
Sprinkler	527.82	67.2	Remocal et al. 2021
Flush flooding	1610.56		
Drip Irrigation	847.88	33.9	Pascual et al. 2022
Surface flooding	1283.5		

*average values

OTHER WATER MANAGEMENT-TECHNOLOGIES

Fuel Saving for Pump Irrigation

The increasing cost of fuel in the market makes it difficult for rice farmers to continue producing rice in the rainfed area. In response to this inevitable problem, PhilRice developed a gasifier engine pump system for tapping energy from the rice hull as an alternative solution for the fuel requirements in pumping irrigation water. The local design of the stationary rice hull gasifier-engine pump system was based on the working designs of the University of California Davis for the batch-fed throat less combustor component and the New Energy Development Organization project of Japan on the gasification (Juliano et al. 2010). However, the stationary design was further improved to address space requirements for installation and turned the gasifier into a mobile one for ease of transport from one field to another. The outstanding design feature of the mobile rice hull gasifier engine pump system is lightweight and compact and can save 34-44% on fuel cost for irrigation.

A hydraulic ram pump was also used in suitable rainfed areas to irrigate rice and rice-based crops. It is a cyclic water pump powered by hydropower, wherein the pump pushes water uphill using energy from falling water. It is inexpensive and does not require an outside energy source to operate (Ganotisi et al. 2014). Other renewable sources of energy for pumping water were hybrid wind-solar coupled with low-cost drip irrigation and modified wind-pump irrigation system (Ramos et al. 2015; Bautista et al. 2015)

The solar-powered fertigation system of the Department of Agriculture was introduced to the small-scale irrigation projects, which was designed to increase cropping intensity and crop production, farm income, and employment. It is an irrigation system powered by solar energy with the integration of low-pressure fertigation tanks. The system provides water and nutrient requirements at the pre-determined right time and quantity. Solar pumping can help offset the cost of traditional irrigation fuels like gasoline and diesel. The low operational cost and zero carbon emissions make the solar-powered irrigation system outstanding for rice production. Using this technology, farmers could produce high yields of crops all year round to reduce the scarcity of food supply in the country.

Development of an Irrigation Advisory Service

The irrigation advisory service aims to provide a decision-support tool to assist stakeholders in managing irrigation water at farm and water-basin levels (Figure 2). It is anchored on a scientifically proven method for irrigation using the recommended safe AWD that improves water use efficiency and management (Regalado et al., 2019). The IAS focuses on using AutoMon^{PH} (Automated Monitoring), developed and tested by IRRI and PhilRice. It is a sensory-based irrigation scheduling that uses wireless data networks to measure the field-water level remotely (Yadav et al., 2020). The infrastructure (database and algorithms) of the IAS was organized and stored in a unified electronic warehouse located at PhilRice, where real-time analytics platforms were created for decision making, monitoring, and learning (Regalado et al., 2019). To date, the performance of the IAS is continuously tested at a turn-out scale to improve the functionality and workability from plot to command area of the irrigation scheme.

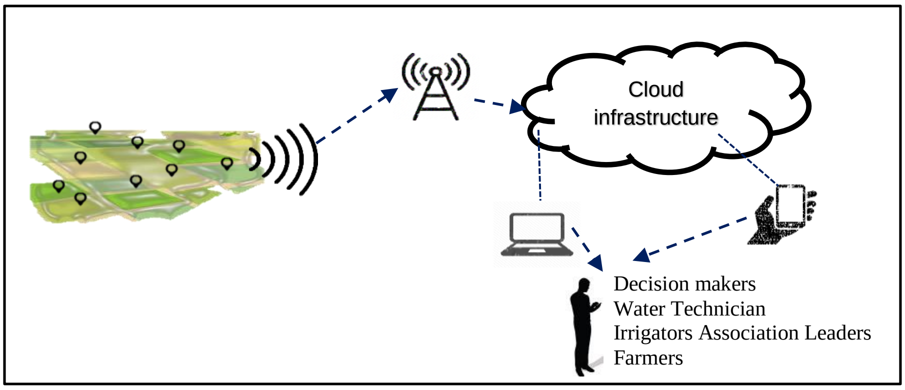

Figure 3. Conceptual framework of the irrigation advisory services in the Philippines (Adapted from Regalado et al. 2019)

THE WAY FORWARD

The issue of water scarcity and the effects of climate change emphasizes the need to continuously develop innovative ways to grow rice while promoting water-saving technologies and practices already available to the farmers. However, the relative attractiveness of these water-saving technologies still depends on various factors, such as the degree of water scarcity, the level of farmer's control over the irrigation, the condition of infrastructure, and farmer's socioeconomics condition in rice farming. Thus, identifying hot spots or areas with a high potential to improve water productivity and efficiency is vital to tailor-fit specific solutions to specific water-related problems.

There have been significant advances in spatial and temporal information-modeling and simulations and using a geographical information system that can help identify major hotspots of irrigation water uses, water availability, rainfall pattern, and other hydrological variables that would help understand water resources and water dynamics in a locality or within a basin. The information will enable decision-makers, extension workers, and researchers to scale-out water-saving technologies and develop tailored-fit solutions to the problem.

Decision-support tools that inform farmers are critical, especially those under the large-scale irrigation system where farmers have relatively no control over the release of irrigation water. The creative use of information technologies and IoT-based water management should be pursued and intensified using sensors, controllers, computers, and mobile phones for irrigation scheduling and advisories. The existing framework of the AutoMon^{PH} needs to be further tested to improve the performance at the system level. This requires collective action to synchronize the water demand within the basin. Furthermore, the active roles of farmers and decision-makers in water management within the irrigation advisory services should also be institutionalized and redefined. This can be done with better coordination, cooperation, and partnerships from farmers to irrigation managers and policymakers.

Furthermore, to complement AutoMon^{PH}, water availability in the reservoir for precise water budgeting and equitable irrigation allocation through a sensory-based water monitoring system is also essential. A thorough understanding of the supply and demand of water in the canals and basins can assist the planning and allocation of equitable irrigation distribution at the right time and location. Thus, it is essential to revisit and conduct field measurements on the inflow and outflows to estimate the demand for precise water budgeting.

Other researchable gaps that need further investigation are the re-use of drainage water and smarter ways to address frequent dry spells in rainfed areas. The impact of reducing water inputs in terms of nutrient imbalances in the soil and groundwater recharge also needs further investigation for sustainability.

Overhead irrigation, pivots, lateral moves, low-pressure irrigation, and runoff recycling must be explored while continuously promoting the best crop and water management technologies to improve water and crop productivities. Moreover, water quality, an oft-neglected problem in irrigation systems, warranted further research.

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THE RAINLESS PERIODS IN CENTRAL HUNGARY AS A STOCHASTIC PROCESS OF EXTREMES

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ABSTRACT:

The impact of climate change in the Pannonian region is evidenced by increased drought frequencies and their intensity and changes in precipitation distribution. No-rainfall and less than normal rainfall (‘drought’) events during the growing season are also more frequent, which is significant in the region because the national economies of ten 'involved' countries (and especially Serbia and Hungary) are largely dependent on agricultural production. In this paper, we analyze such drought events and provide estimates of their number per season and duration of the longest events, including their return periods (2, 5, 20, 50, and 100 years). The principal assumption is that a single drought event can be represented by the number of consecutive days without rain, or with the rain of a defined reference-small amount. In turn, extracted no-rainfall events in a given historical record of daily rainfall are treated as a realization of a corresponding stochastic process. Events in the multiyear daily rainfall record have specific identifiers: (a) an event is a period without rain, or with rainfall, less than 3 mm per day, (b) an event belongs to the growing season, and (c) neighbor events are checked for possible merging. In this way, the analysis is focused on ‘agricultural droughts’ as random events as they are in reality. The extreme events (mostly with a duration longer than 20 consecutive days) are modeled and analyzed for 7 selected locations (grid cells in the CARPATCLIM database) in Central Hungary. The analysis is based on the historically recorded series of daily rainfall for 30 years (1991–2020). Theoretical distributions are determined by the number of droughts per growing season (Poissonian), the duration of all droughts (exponential), and the duration of the longest droughts (double exponential). The results for the location closest to Budapest are presented in more detail.

Keywords: extreme rainless period, growing season, stochastic process, Budapest area

INTRODUCTION

The climate change-related effects of extreme rainfall-runoff or extreme rainfall deficit have diverse impacts (Beersma and Buishand, 2007; Katz *et al.*, 2002; Mishra and Singh, 2011; Srdjevic *et al.*, 2018, Srdjevic *et al.,* 2020, Srdjevic *et al.*, 2022). On one side surface and sub-surface runoff is the result of rainfall’s transformation, deep percolation, or torrential flows during heavy rainfall events, while on the other side long no-rainfall periods, as a result, lead to agricultural and other sector-related drought events. Case studies in different countries focus on the consequences of extreme meteorological events and on measures for mitigating associated risks (Steinemann, 2006; Tabrizi *et al.*, 2010; Tallaksen *et al.*, 1997), especially those related to food supply chains and the agriculture sector, with its connections to other sectors, from industry to trade.

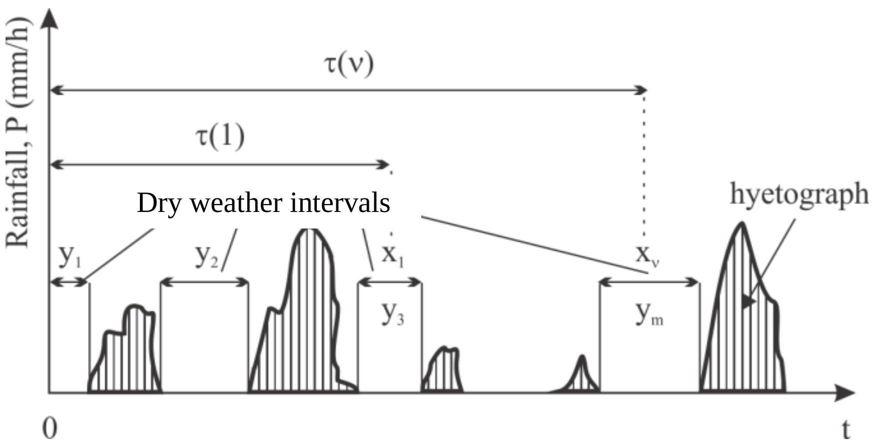
In this paper we present the initial result of the comprehensive stochastic analysis of the rainless periods in the Pannonia Basin, starting with an area in Central Hungary. Historical daily rainfall data are used for 7 selected locations in Hungary (the period covered was 1991-2020). The ZT stochastic method (Todorović and Zelenhasić, 1970; Zelenhasić, 2002) is applied to completely analyze extremely long rainless periods and determine the probability distributions of the number and duration of such periods. The research framework of this study takes into account an agricultural perspective of rainless events and the results presented for one location close to Budapest serve to demonstrate the approach and strategy to be followed in future research for territories of Hungary and Serbia.

MATERIAL AND METHOD

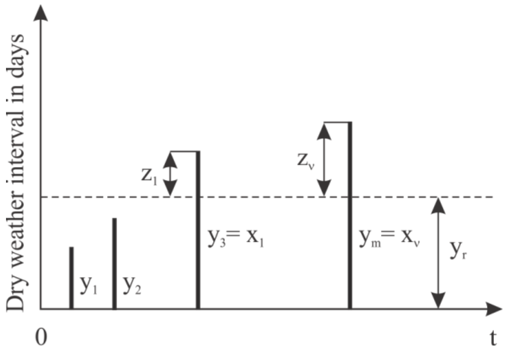
Extremely long rainless periods at seven locations in Central Hungary (Fig 1) are analyzed by the ZT method aimed at the complete stochastic analysis of extreme events. The method is mathematically complex with seven modules. It will be only briefly introduced here regarding the modules used in this study. For more details about the method and its different versions consult pertinent literature and most recently presented mathematical descriptions in Srdjevic *et al.* (2018, 2020, 2022). The results of the ZT method application for one grid point in the CARPATCLIM database (Szalai *et al.*, 2012; Spinoni *et al.*, 2014) close to Budapest, the capital of Hungary, will be presented in this study.

Figure 1. Selected 7 meteorological stations in Central Hungary

Theoretically established in the early 70-ties of the last century, the ZT method evolved through time and in different versions used to enable analyses of flood peaks, low river flows, and rainless periods. The principal assumption in treating rainless periods by the ZT method, which is the case here, is that a single rainless event can be represented by the number of consecutive days without rain, or with the rain of a defined reference-small amount (Fig 2). If the event is longer than the reference duration (here 20+ days) then that event can be called ‘agricultural drought’, or shorter ‘drought’.



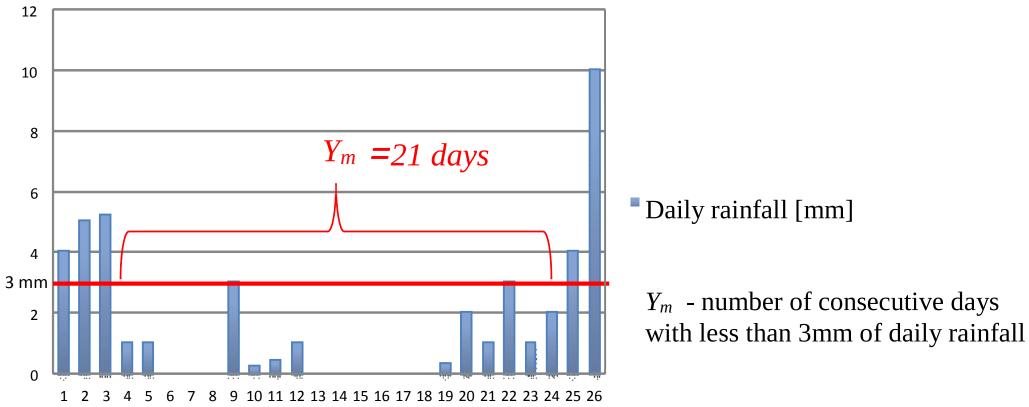
(a)



1 April - 30 September

(Y_m - number of consecutive days with less than the reference value of mm of rainfall)

(b)



(c)

Figure 2. Rainless events: definition and identification (Srdjevic et al. 2020)

If for a given station or grid cell in a database there is a historical multiyear record of daily rainfalls, it is possible to extract no-rainfall events during the growing season (1 April – 30 September in this part of Europe) each year and create a specific discrete realization of a corresponding stochastic process of droughts. If the following set of assumptions is adopted as introduced in Srdjevic et al. (2018, 2020), the three important distributions of the probabilities for the process can be analyzed: (1) Poissonian distribution of the number of droughts; (2) exponential distribution of probabilities of occurrence of all droughts; and (3) double exponential distribution of probabilities of occurrence of the longest droughts. Complete mathematical elaboration of these components of the process is given in Srdjevic *et al.* (2018, 2020) and is avoided hereafter.

For a better understanding of the results, worth mentioning are the following key definitions adopted in this study: (a) an event (drought) is a period at least 20 consecutive days long, without rain, or with rainfall amount lower than 3 mm per day, (b) a drought entirely belongs to the growing season, and (c) neighbor rainless periods have to be checked and possibly merged. In this way, the analysis can be focused on ‘agricultural droughts’ as random extreme events as they are in reality.

The extreme events are analyzed at seven grid cells from the CARPATCLIM database with daily rainfall records for a period of 30 years (1991–2020).

RESULTS AND DISCUSSION

Results of the basic statistical analysis of a 30-year long period of historical rainfalls show that in the period 1991-2020 there were 37 droughts during the growing season (each year, only period 01.04. – 30.09. is analyzed). The number of years without droughts is 9. The longest drought occurred in 2011. and lasted for 59 days which corresponds to the probability of occurrence once in 50 years.

The ZT method application for the grid location near Budapest labeled as No 6. in Figure 1 can be summarized as follows:

(1) Poissonian distribution function (number of all droughts):

$$P(E_k) = e^{-\lambda_1} \cdot \frac{[\lambda_1]^k}{k!} \quad \text{where } \lambda_1\text{=37/30=l.233333, and k=0,1,2, 3...}$$

(2) Distribution of all droughts:

$$F(Z) = 1 - e^{-\lambda_2 \cdot Z},\ Z \geq 0,\ \lambda_2 = 0.154131$$

(3) Distribution of longest (yearly) droughts:

$$F(Z_{max}) = e^{-\lambda_1 \cdot e^{-\lambda_2 Z}},\ Z \geq 0,\ \lambda_1\text{=l.23333},\ \lambda_2 = 0.154131$$

The double exponential distribution function (3) of the longest droughts duration with parameters λ_1 and λ_2 enables determining statistically important information about return periods of the longest (yearly) droughts by using the formula:

$$T = \frac{1}{1-F(Z)}\,.$$

Computed return periods for station 6 are presented in Table 1. Once in two years, the rainless period can be expected to be 25 days long without rainfall or with rainfall less than 3 mm. A 100-year drought can expectedly be 66 days long.

Table 1 Return periods of longest droughts
for grid location No. 6 at Fig.1

Return periods (years)	**Drought (days)**
100	66
50	59
20	50
10	43
5	36
2	25

CONCLUSIONS

This study has been focused on rainless events of extremely long durations from an agriculture perspective. In the 1991-2020 period, daily rainfall data are used for selected locations in Central Hungary. The research team consulted the agronomists in Serbia and Hungary to better define meteorological droughts as rainless periods, establish necessary parameter sets and apply the scientifically recognized ZT stochastic model of extremes to enable understanding of what is going on with obvious negative impacts of climate change. After consultations with experts from academia and with many local farmers (landowners and/or irrigators) (Srdjevic *et al.*, 2018, 2020, 2022), it was concluded that Serbian and Hungarian agriculture is diversified in terms of types of soil and plant coverage, topography and 'dynamics' and level of development of the society and its economy, and that the reference values for drought identification (20 days and longer; up to 3 mm of rain) fit best to the situation in two countries, and even broader throughput Pannonia Basin. The results of this study will expectedly be extended with the results obtained for more meteorological stations (or locations from the CARPATCLIM database) to enable mapping of the longest droughts. With the addition of other statistical analyses, it will be possible to shape the framework for better mitigation of risks related to agriculture, compensating deficits of rainfall (and rainfall-related sources of water) by other agricultural measures such as irrigation or structural improvements in water resources infrastructure.

Acknowledgment

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REASONS OF MEADOW HAY SCARCITY IN KARCAG REGION

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ABSTRACT

We analysed the situation of the peak water demand before harvesting (beginning of flowering) of the grassland vegetation and the main crop in a meadow on a meadow with solonyec soil in Great Kunság, a Natura2000 site in an arid climate, and analysed 12 years (2010-2021), in comparison with the amount of meadow hay produced in the given year. From the March-April precipitation and heat totals for each vintage, a climate index was constructed to determine the annual pre-mowing precipitation deficit or surplus for the period before the one-time mowing that determines the annual hay yield. Based on our results, we found that in only 3 of the 12 years studied did the harvested hay yield meet the winter fibre fodder requirements of our sheep flock. For the last 5 vintages (2017-2021), none of them produced sufficient hay from the field. For the three years with good hay yields (2010, 2013, 2016), the higher rainfall in the first decade of May allowed to increase the production of the grassland phytomass, in coordination with the shift in the timing of mowing.

Keywords: grass irrigation; flood irrigation; water norm; drainage; yield

INTRODUCTION

Nowadays, most Hungarian grasslands are locked into environmental regulations (albeit with remarkable subsidies), relying almost exclusively on the natural nutrient availability of their soils and climatic conditions for their phytomass yield.

The yield of natural grassland is nowadays entirely dependent on the season, and it is on this unpredictable fodder base that livestock sectors which primarily consume grassland vegetation, such as extensive sheep farming, should be based.

The main problem is that, although grassland is nowadays managed with almost zero input, it is a water-intensive crop, whose water requirements are less and less satisfied by rainfall (Gruber, 1964). It is noteworthy that Dimitrijev (1948) found that the transpiration coefficient of grassland is twice that of sugar beet.

Baskay-Tóth (1962) and Szabó (1973) explain that soil water relations have a much stronger influence on the yield of grassland than on that of arable crops. The water requirement of grassland plants is highest from the time of shoot initiation to the flowering phenophase. In grass and mowing applications, i.e. when the economic purpose of the first growth is hay production, a so-called peak demand occurs at the beginning of flowering, at the optimum of mowing. He calculates that ~4 mm of surface water is required to wet 1 cm of bound topsoil. Since 90% of the root zone in natural grasslands is located in the 0-10 cm soil level, ~40 mm of water is required to re-wet the critical top 10 cm.

Nagy (1964) and Nagy and Vargyas (1988) explain that autumn-winter precipitation is generally sufficient for the production of carbon from the main stem of native grassland. Until recent years of climate change, this finding held. Nagy (1980) and Szemán (2006) already write about the possible need for early spring irrigation of ancient grasslands, suggesting a 60 mm irrigation water dose.

The objective of our manuscript is to provide plant-level data to clarify the relationship between the hay yields of a grassland area under Natura 2000 over 12 seasons and the indicators calculated from the site rainfall and heat data.

MATERIALS AND METHODS

Our studies were carried out between 2010-2021 at the Hungarian Agricultural and Life Sciences University Research Institute Karcag (hereinafter: MATE KKI) on Rainer grassland (hrsz:01712/1). The total area of 180.5 ha of meadow is a grassland community of *Achilleo-Festuceteum pseudovinae* with a solonyec soil, which forms a mosaic transition with *Agrosti-Alopecuretum pratensis* meadow in the lower parts. 120 ha are under grassland management, the rest being used as permanent pasture and beaver pasture. The sheep farm in the middle of the site provides annual feed for 500 ewes and their young on the extensive grassland above. Grassland management is supported/impeded by the fact that the site is covered by Natura 2000. The grass yield is seasonal. The mowing period coincides with the beginning of flowering of the dominant grass species (*Alopecurus pratensis, Festuca pseudovina, Poa pratensis subsp. angustifolia*), therefore mowing was carried out between 1-15 May. The sheep's annual meadow hay requirement is 400 round bales of 125×165 cm (about 140-150 thousand kg in total), in addition to litter hay and abrac. The round bales were produced using a Welger RP-320 round baler with an average weight of about 360 kg/bale. For our study, we used temperature and precipitation data from the MATE KKI Meteorological Monitoring Station, which are presented in the following table (Table 1.).

Table 1. Average temperature, temperature sum and precipitation sum in March and April (2010-2021, Karcag)

	Average monthly temperature (°C)		Monthly heat sum (°C)		Monthly precipitation sum (mm)	
	March	April	March	April	March	April
2010	6.0	11.4	190.9	340.6	12.1	63.3
2011	6.0	13.1	188.0	384.0	22.0	18.9
2012	7.0	12.3	211.1	356.6	2.5	13.1
2013	3.8	12.8	120.1	378.0	110.2	47.3
2014	9.3	12.6	294.0	384.5	20.0	46.5
2015	6.9	11.0	216.1	316.8	13.3	11.0
2016	6.8	12.7	207.9	378.1	26.8	17.9
2017	8.8	10.6	267.8	311.5	21.3	45.7
2018	3.2	16.1	102.6	483.6	79.7	13.7
2019	9.0	12.9	272.2	391.8	8.8	47.3
2020	6.6	11.5	207.4	334.3	34.4	9.8
2021	5.4	8.7	167.0	257.9	5.6	23.3

Vinczeffy (1993), based on several years of operational experiments, refined the investigation of the adequate precipitation-heat requirement for grassland production in Hungary and called it the climate index, which is the characteristic of the given period in relation to the optimum value of 0.200-0.250 mm/°C. It also found that the lower value of the optimum climate index (0.200 mm/°C) multiplied by the sum of the temperatures gives the optimum precipitation numbers. Based on this, we calculated the optimal precipitation for the months of March and

April for the period 2010-2021, and calculated the precipitation surplus or deficit compared to the optimal precipitation (Table 2.)

Table 2. Precipitation optimum and precipitation deficit/surplus in March and April (2010-2021, Karcag)

	Monthly precipitation optimum (mm)		Monthly rainfall deficit / surplus (mm)	
	March	April	March	April
2010	38.18	68.12	-26.08	-4.82
2011	37.60	76.79	-15.60	-57.89
2012	42.21	71.32	-39.71	-58.22
2013	24.01	75.60	86.19	-28.30
2014	58.79	76.89	-38.79	-30.39
2015	43.22	63.36	-29.92	-52.36
2016	41.57	75.62	-14.77	-57.72
2017	53.55	62.29	-32.25	-16.59
2018	20.52	96.71	59.18	-83.01
2019	54.44	78.36	-45.64	-31.06
2020	41.48	66.85	-7.08	-57.05
2021	33.40	51.57	-27.80	-28.27

Vinczeffy (1993), defined the values of the climate index as 0.05 mm/°C –desert; 0.075 mm/°C –semi-desert; 0.1 mm/°C –arid; 0.125 mm/°C –dry; 0.15 mm/°C –slightly dry; 0.175 mm/°C –medium; 0.2 mm/°C –fresh; 0.225 mm/°C –optimal; 0.25 mm/°C –slightly rainy; 0.3 mm/°C –rainy; above 0.3 mm/°C –very rainy. Since the calculation of the climate index is a fully accepted scientific and practical method in Hungarian grassland management, the monthly precipitation-heat calculation of our experimental period was based on the method. The climate index by month was calculated on the basis of his calculations (Table 3.), and then the nature of the months was classified into the categories he provided. The following formula (1) was used to determine the climate index for each month:

RESULTS

Our table below shows the hay yield harvested and the number of bales for the study period 2010-2021 (Table 4.).

Our table shows that the amount of hay bales needed to maintain the sheep was only available in 3 years (2010, 2013, 2016) during our experimental period. In particular, we would like to highlight that in 2010 the amount of hay harvested was double the amount needed to feed the sheep in winter.

In order to maintain a continuous production, we were forced to supplement the winter feed supply of the sheep with field straw (e.g. millet straw). Furthermore, it can be seen from our table that the last 5 years of our experimental period were a period of hay shortage due to inadequate rainfall supply, with an average 20% less hay production. However, the average hay yield of the 12 years (401 bales) reaches the amount of hay needed for winter feeding of sheep, but always the poorest year of the year should be counted as the one with the highest animal carrying capacity of the area (249 bales in 2017).

Table 3. Monthly climate index and its value for March and April (2010-2021, Karcag)

Climate index (mm/°C) = monthly precipitation sum (mm) / [monthly mean temperature (°C) × number of days in month] (1)

	Values of monthly climate index (mm/°C)		Monthly climate index (mm/°C)	
	March	April	March	April
2010	0.065	0.185	semi desert	medium
2011	0.119	0.048	dry	desert
2012	0.011	0.035	desert	desert
2013	0.926	0.123	very rainy	dry
2014	0.070	0.123	semi desert	dry
2015	0.062	0.033	semi desert	desert
2016	0.128	0.047	dry	desert
2017	0.078	0.143	semi desert	slighty dry
2018	0.793	0.028	very rainy	desert
2019	0.032	0.122	desert	dry
2020	0.168	0.028	medium	desert
2021	0.034	0.090	desert	arid

Descriptive statistics were used to evaluate the data using Microsoft Excel.

Common to the 3 years with outlier hay yields was that the first decade of May was replaced by a monsoonal rainfall during the dry period, with 124.8 mm in May 2010, 81.9 mm in May 2013 and 37.1 mm in May 2016 (Table 5). This amount of rainfall was very favourable for hay production.

DISCUSSION

In all cases, favourable years are followed by several years of low carbon yields, in line with Vinczeffy's (1993) finding that extensive grassland in high carbon years depletes nutrients from the soil and results in lower carbon yields.

In the meadow use mentioned by Tóth Baskay (1962) and Szabó (1973), peak water demand before mowing in the three outstanding years of the pasture, our data show that the two months before harvest were predominantly desert and semi-desert in terms of climatic index, but in all cases a monsoonal rainy period in May increased the amount of undergrowth (*Poa pratensis subs.).* In May 2010, for example, 124.8 mm of rain fell, and annual rainfall was 889 mm. Nevertheless, March 2010 was semi-desert and April 2010 had a medium climate index.

The good hay yield was helped by the rainy May, which has so far arrived after every dry drought spring, although in 2002 and 2003 this rainfall did not arrive and only 75 and 51 bales respectively were harvested from the 120 ha of grassland.

Table 4. Annual hay yield between 2010-2021 (Karcag)

	Hay (kg^{-1})	Bale (piece)
2010	291600	810
2011	115500	321
2012	121400	337
2013	215000	594
2014	122600	341
2015	112500	313
2016	180300	501
2017	89700	249
2018	117600	327
2019	134400	373
2020	120200	333
2021	114500	318
Mean	144608.33	401.42
Standard Error	16534.52	45.83
Median	120800.00	335.00
Standard Deviation	57277.26	158.76
Sample Variance	3280684469.70	25204.08
Kurtosis	3.38	3.44
Skevness	1.89	1.90
Range	201900.00	561.00
Minimum	89700.00	249.00
Maximum	291600.00	810.00
Sum	1735300.00	4817.00
Count	12.00	12.00

Table 5. May 2010, 2013, 2016 meteorological data and climate index values

	2010	2013	2016
Average temperature (°C)	16.8	17.3	16.3
Heat sum (°C)	503.2	535.9	495.7
Precipitation sum (mm)	124.8	81.9	37.1
Precipitation optimum (mm)	100.64	107.18	99.14
Rainfall deficit/surplus (mm)	24.16	-25.28	-62.04
Value of climate index (mm/°C)	0.240	0.153	0.073
Climate index (mm/°C)	optimal	dry	desert

It is recommended that when buffering hay in a favourable year, efforts should be made to store it with as little loss as possible, as the supply of meadow hay from the market is very low in our country. Furthermore, in our country, grassland is typically drained in the summer, so harvesting hay is justified in order to ensure winter fodder supply and to increase the intensity of the technology (e.g. compressed manure). Since the ancestral grasslands provide 70-80% of the annual phytomass in the main season, further studies should be carried out with early spring irrigation of these grasslands to ensure continuity of the animal production capacity of these areas.

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ASPECTS REGARDING THE EVOLUTION OF ROMANIAN BUSINESSES RELATED TO COLLECTION OF NON-WOOD FOREST PRODUCTS FROM SPONTANEOUS FLORA

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ABSTRACT

Located in S-E Europe, with an area measuring 238,397 km^2, Romania is a country with a varied and proportionate relief (31% mountains, 36% hills and plateaus, 33% plains and meadows). Romania's forest fund covers an area of 6,592 thousand hectares (27.7% of the country's surface), 6,427 thousand hectares being occupied by forests (28.8% resinous species and 70.2% deciduous species). Living environment for plants and animals, forests are a complex ecological system, representing an inexhaustible source of oxygen, an environment for relaxation and recreation, but also a source of income. Over time, through their products, forests have contributed to the socio-economic well-being of local communities. Forests are an important economic resource, not only for wood (green gold), but also for non-wood forest products from spontaneous flora, around them have developed businesses whose object of activity is the collection of materials from spontaneous flora (mushrooms, truffles, berries, forest seeds, medicinal and aromatic plants, resins, etc.). The number of companies in the field of collecting non-wood forest products from spontaneous flora was in 2020 in Romania of 88, these cumulating a turnover of 57,356,060 Euro, a net profit of 2,387,033 Euro and registering an increase of 20.27% compared to 2019. In this article, the authors present the evolution of the business in the field of collecting non-wood forest products from spontaneous flora in terms of the main indicators of financial performance (turnover, profit, number of companies, number of employees, profit margin, sales).

Keywords: businesses, Romania, non-wood forest products, spontaneous flora

INTRODUCTION

According to FAO's Forest Resource Assessment, non-wood forest products (NWFPs) are "Goods derived from forests that are tangible and physical objects of biological origin other than wood". Category of NWFPs includes those products who can be used as food and food additives (edible nuts, mushrooms, fruits, herbs, spices and condiments, aromatic plants, game), fibres (used in construction, furniture, clothing or utensils), resins, gums, and plant and animal products used for medicinal, cosmetic or cultural purposes (About non-wood forest products. FAO).

Non-wood forest products fall into the category of important products in various aspects for people around the world (Global Forest Resources Assessment 2000).

For rural and poor people, NWFP are a source of food, animal feed, building materials, and even medicine. For many people, marketing NWFP means providing for their daily needs and even a job. Internationally traded NWFPs contribute to economic development. NWFPs are generally used for subsistence and locally by small businesses (Global Forest Resources Assessment 2000, Global Forest Resources Assessment 2020. Key findings 2020).

Also FAO mention that for millions of households around the world, the NWFP is a way of earning a living. About 80% of the population in developing countries use NWFP to meet their health and nutrition needs. In general, women in poor households are the ones for whom the

NWFP is a way to earn an income. NWFP is considered also a raw material for various industrial sectors and export goods (at least 150 NWFPs are traded internationally). Another aspect of the NWFP is their contribution to achieving environmental goals, including the conservation of biological diversity (About non-wood forest products. FAO).

Even if they are of real importance, unfortunately the national institutions monitor the resources and do not evaluate the socio-economic contribution of the NWFP, as is the case with wood and agricultural products. Consulting the statistics reveals that there are few countries that monitor the use of NWFP (Vasile et al 2017; Global Forest Resources Assessment 2000; Positioning non-wood forest products in agricultural statistics).

In recent years there has been an increase in interest and activities related to the NWFP, especially regarding their socio-economic role. In this regard, numerous projects are underway to promote the use and marketing of NWFP in order to support local economies, rural communities and forest conservation. This encourages the monitoring of forest resources and their use, which is not an easy task. The difficulty is due to the multitude and diversity of products, the numerous uses at local, national and international level, the different interests, but also the lack of a common terminology and units of measurement (Martínez de Arano et al 2021; Sorrenti 2017; Global Forest Resources Assessment 2000; Naturally Beautiful. Cosmetic and beauty products from forests)

Starting a business in Romania involves going through certain stages and fulfilling certain conditions according to the applicable legislation (Law no 31 /1990).

One of the obligations that must be fulfilled when setting up any business is to specify the object of activity, the field and the main activities. According to CANE (Classification of Economic Activities in the National Economy), businesses whose activities are related to the collection of non-wood forest products from spontaneous flora are included in class 0230 (Order no 337 from April 20th 2007).

Class 0230 includes the collection of spontaneous flora materials, such as mushrooms, truffles, berries, nuts, bales and other gums, cork, balms, varnishes and resins, vegetable yarns, grass, acorns, chestnuts, mosses and lichens, and excludes directed production of these products (except for growing cork trees), growing mushrooms or truffles, growing fruit or shrubs, gathering firewood, producing wood chips. The operation of these types of businesses requires an environmental permit.

Even if the non-wood forest products from the spontaneous flora represent a small volume compared to that of the wood products, they are capitalized in larger or smaller quantities, depending on the knowledge of their qualities, respectively the manifestation of the demand towards them.

Among the non-wood forest products of spontaneous flora, special attention is paid to berries, especially due to their high vitamin content. It is known that berries have a higher mineral content than cultivated fruits, the best represented mineral element being potassium. The forest products of the spontaneous flora recognized for the high content of vitamin C (sorbic acid) are: rosehips (150-9000 mg/100g), sea buckthorn fruits (100-1000 mg/100g), black currants (200mg/100g), cetin fir and pine (150-250 mg/100g) etc. The importance of vitamin C for the human body is given by the fact that it is the main anti-infective food available to humans.

As mentioned above, there are no statistics that strictly refer to non-timber forest products, and where they do exist, they do not necessarily reflect the reality, as it is difficult to distinguish between forest and agricultural products. Regarding Romania, according to "statistical data", in 2015 the production of berries (*Rubus idaeus, Vaccinium myrtillus, Rubus caesius*) a total 3,482 tonnes, medicinal plants (*Sambucus nigra, Tilia sp., Crataegus monogyna, Betula pendula, Vaccinium myrtillus* (leaves), *Urtica dioica, Hypericum perforatum, Achillea millefolium, Rubus idaeus, Plantago sp., Robinia pseudacacia, Equisetum arvense, Primula oficinalis,* *Matricaria chamonilla*, *Hypericum perforatum*, etc.) 660 tonnes, mushrooms (*Boletus edulis*, *Armillaria melea*, *Cantharellus cibarius*) 543 tonnes, honey 731 kg, osier 45 tonnes and forest seeds 7 tonnes (Global Forest Resources Assessment 2020. Report Romania, FAO, Rome).

The purpose of the article is to present the evolving business related to the collection of non-wood forest products from spontaneous flora in terms of financial performance in the period 2011-2020.

MATERIALS AND METHODS

The steps that were taken in the elaboration of the article are the following: establishing the purpose of the article, selecting and studying the specialized literature and statistical reports, analyzing and interpreting the data, drawing conclusions.

In order to achieve the proposed goal, the authors of the article used statistical observation as a research method. The information presented in the article is the result of the analysis and interpretation of data from statistical reports and literature that are mentioned in the bibliography. Graphical representations were used to present the evolution of financial performance indicators.

For the euro expression of the values of the analyzed indicators was used an average value for the year 2020 of the euro currency of 4.837 lei (Romanian currency).

RESULTS AND DISCUSSIONS

According to the information provided by Sectorial Study. Collection of non-wood forest products from spontaneous flora, 2020, the number of companies operating in this field, the number of employees and the average number of employees experienced a slight fluctuation in 2011-2020, as can be seen in Figure 1.

Regarding the main indicators of financial performance (turnover, net profit and profit margin) the trend is increasing in the analysed period, even if there were years in which there were decreases in the values of these indicators. (Figure 2)

The average sales per company are also in an upward trend in the 10 years analyzed, except for the years 2013, 2015 and 2016 when there were decreases. (Figure 3)

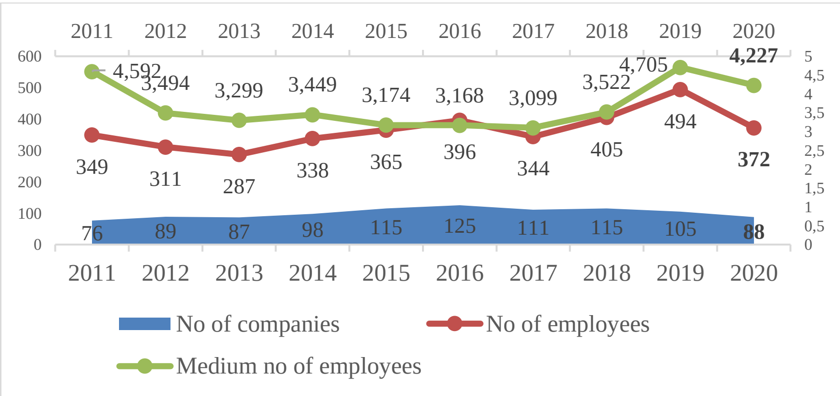


Figure 1. Evolution of Romanian businesses related to collection of non-wood forest products from spontaneous flora

Source: processed after data provided by Sectorial Study. Collection of non-wood forest products from spontaneous flora, 2020

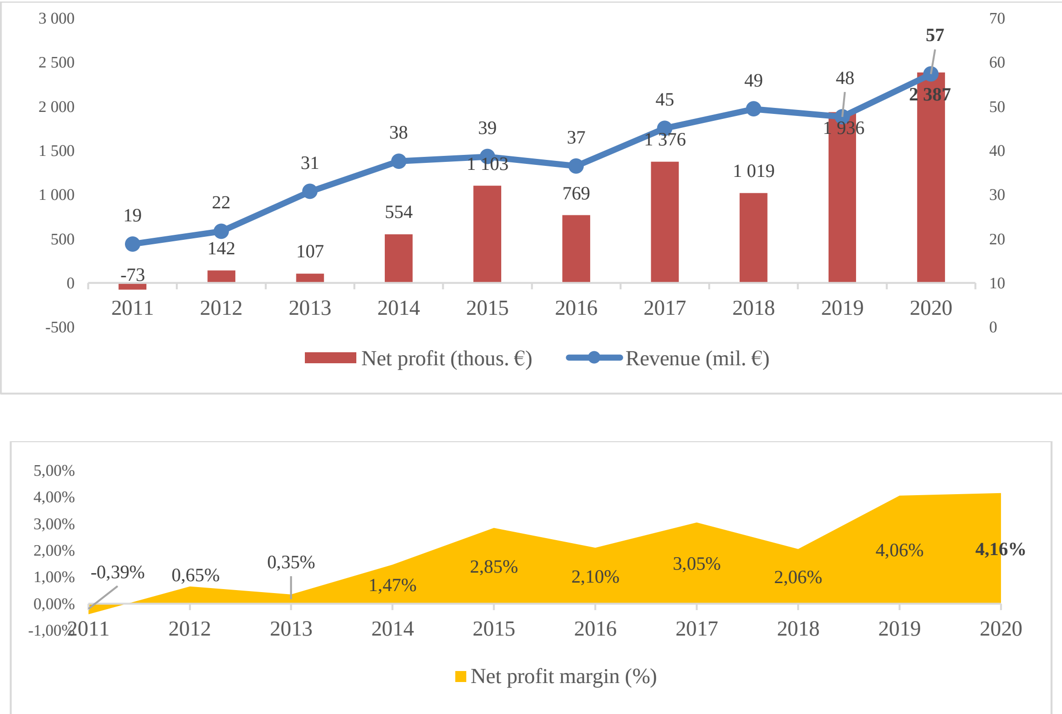


Figure 2. Evolution of main financial indicators

Source: processed after data provided by Sectorial Study. Collection of non-wood forest products from spontaneous flora, 2020

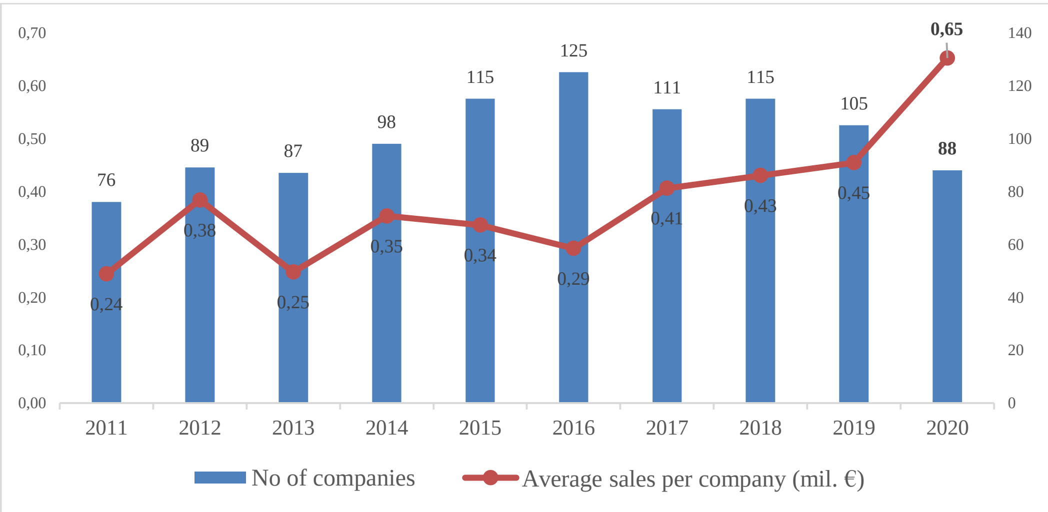


Figure 3. Evolution of the average sales per company

Source: processed after data provided by Sectorial Study. Collection of non-wood forest products from spontaneous flora, 2020

Regarding sales per employee and profit per employee, as can be seen in figure 4, these two indicators also show an increasing trend in the period under review, even if there are years in which there have been decreases.

Figure 4. Evolution of the sales and profit per employee

Source: processed after data provided by Sectorial Study. Collection of non-wood forest products from spontaneous flora, 2020

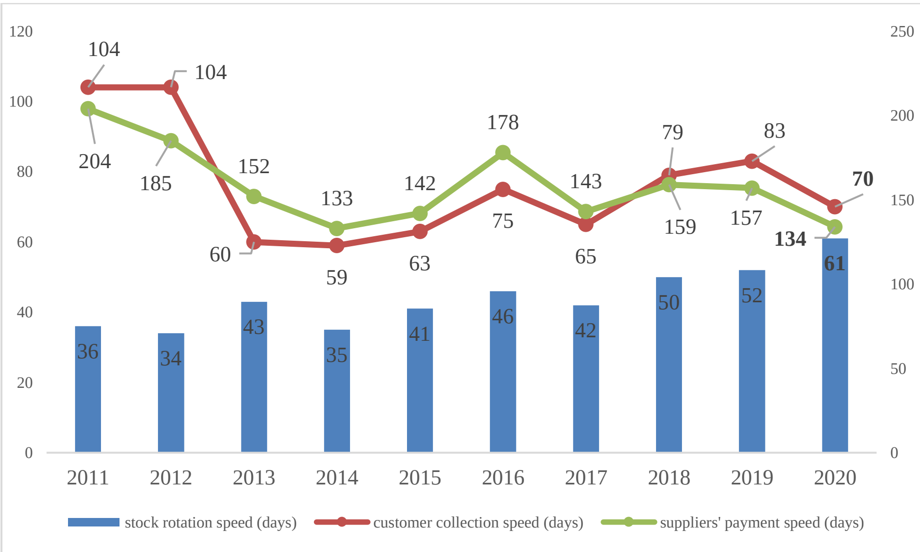


Figure 5. The evolution of the efficiency indicators of the operational activity

Source: processed after data provided by Sectorial Study. Collection of non-wood forest products from spontaneous flora, 2020

Figure 5 shows the evolution of operational efficiency indicators (stock turnover rate, customer collection speed and supplier payment speed), and as can be seen the stock turnover rate increased by 25 days in the year 2011 to 2020. The customer collection speed has reached 70 days in 2020, compared to 104 days in 2011. The payment speed of suppliers shows, as well as the customer collection speed, a decreasing trend, from 204 days in 2011 to 134 days in 2020.

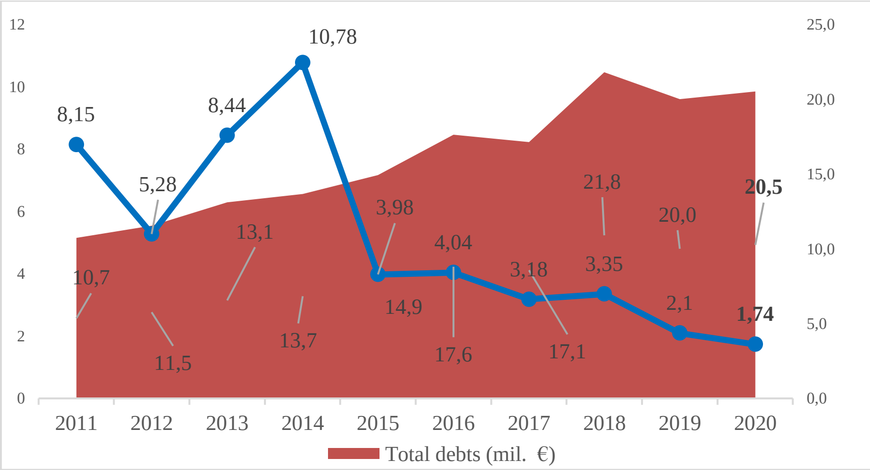


Figure 6. Evolution of financial stability indicators

Source: processed after data provided by Sectorial Study. Collection of non-wood forest products from spontaneous flora, 2020

The total registered debts increased during the analysed period, from 10,737,607 Euro in 2011 to 20,526,500 Euro in 2020, and the total indebtedness rate decreased from 8.15 in 2011 to 1.74 in 2020 (Figure 6).

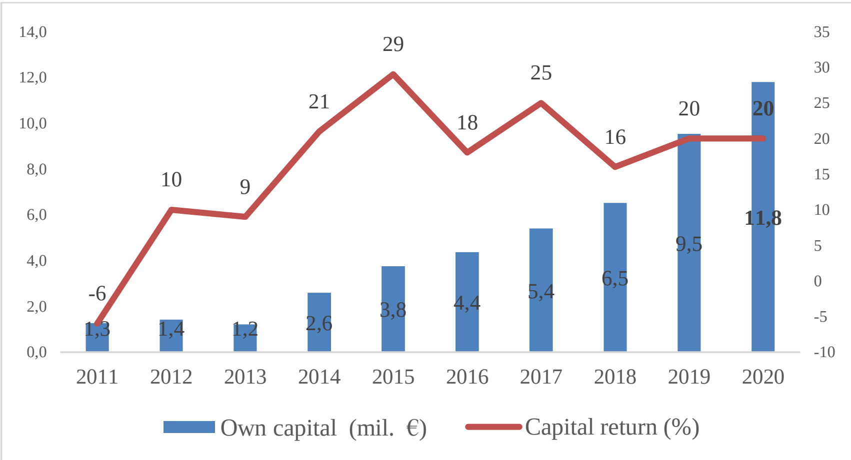


Figure 7. Evolution of the own capital and capital return

Source: processed after data provided by Sectorial Study. Collection of non-wood forest products from spontaneous flora, 2020

During the analysed period, the own capitals registered a continuous increase, as it can be seen from figure 7. And the return on capital is in an increasing trend, but with fluctuations in some years.

The same upward trend is found during the 10 years analysed in the case of fixed assets, receivables, stocks, liquidity and current assets (Figure 8).

Regarding the distribution on the Romanian territory of the companies that carry out their activity in the field of collecting non-wood forest products from spontaneous flora, it can be observed that out of the 41 counties of Romania, plus Bucharest, only 26 companies operate in this field. (Figure 9) The lack of businesses in the rest of the counties is due either to the lack of forests, to the reduced quantities of non-wood forest products from the spontaneous flora or to the lack of interest for the capitalization of these products.

Table 1. Evolution of fixed assets, claims, current assets, stocks and cash (mil. €)

	Fixed assets	Claims	Stocks	Cash	Current assets
2011	4.0	5.3	1.8	0.6	7.8
2012	3.9	6.2	2.0	0.8	9.2
2013	4.1	5.1	3.6	1.0	9.7
2014	5.3	6.1	3.6	1.3	11.0
2015	6.8	6.7	4.4	2.0	13.1
2016	7.7	7.5	4.6	2.0	14.1
2017	8.4	8.0	5.2	2.0	15.2
2018	9.3	10.6	6.7	2.5	20.0
2019	10.6	10.8	6.8	2.1	19.7
2020	**10.7**	**10.9**	**9.6**	**2.6**	**23.2**

Source: Sectorial Study. Collection of non-wood forest products from spontaneous flora, 2020

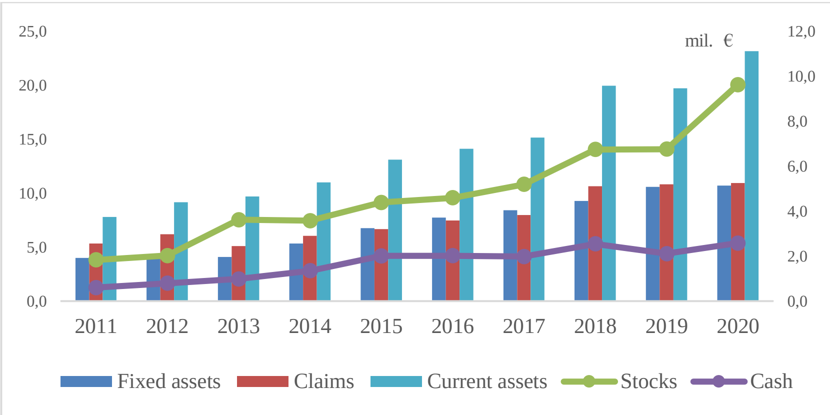


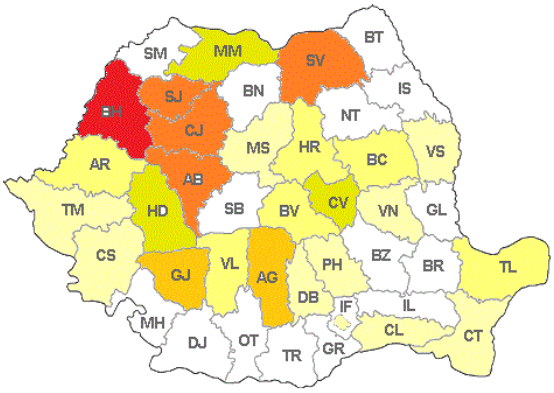
Figure 8. Evolution of fixed assets, claims, current assets, stocks and cash

Source: processed after data provided by Sectorial Study. Collection of non-wood forest products from spontaneous flora, 2020

In addition to the numerical distribution at the county level, when we talk about businesses in the field of collecting non-timber forest products, their financial results (turnover, net profit) are especially important. As can be seen in figure 10, a small number of counties contribute to this sector.

According to the data from figure 10 and figure 11, the activity of the companies that collect non-wood forest products from spontaneous flora is concentrated in Bihor, Salaj, Hunedoara counties, these being the counties with the companies that register the highest turnover.

Regarding the net profit registered by companies at the level of each county, it is observed that the highest values of net profit are attributed to businesses in counties such as Bihor, Salaj, Gorj and Hunedoara (Figure 12).

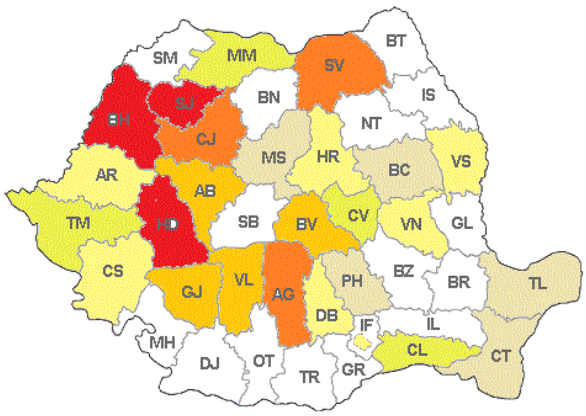


Number of companies/county

17	between 10-6	4	3	2	1
County					
Bihor	Alba (6)	Arges	Covasna	Arad	Bucuresti
	Cluj (9)	Gorj	Hunedoara	Bacau	Calarasi
	Salaj (7)		Maramures	Brasov	Caras-Severin
	Suceava (10)			Harghita	Constanta
				Tulcea	Dambovita
				Valcea	Mures
					Prahova
					Timis
					Vaslui
					Vrancea

Figure 9. Distribution of the number of companies on Romanian Counties

Source: processed after data provided by Sectorial Study. Collection of non-wood forest products from spontaneous flora, 2020



Companies revenue/county

>20 mil. lei 4,134,794 €	10 -20 mil. lei 2 - 4 mil. €	5 - 10 mil. Lei 1 - 2 mil. €	1 - 5 mil. lei 206 thous.-1 mil. €	100 thous.-1 mlei 20 - 206 thous. €	<100 thous. Lei <20 thous. €
County					
Bihor	Suceava	Brasov	Maramures	Dambovita	Tulcea
Salaj	Arges	Alba	Covasna	Harghita	Bacau
Hunedoara	Cluj	Gorj	Calarasi	Caras-Severin	Constanta (0)
		Valcea	Timis	Arad	Mures (0)
				Vrancea	Prahova (0)
				Bucuresti	
				Vaslui	

Figure 10. Distribution of companies' revenue by counties

Source: processed after data provided by Sectorial Study. Collection of non-wood forest products from spontaneous flora, 2020

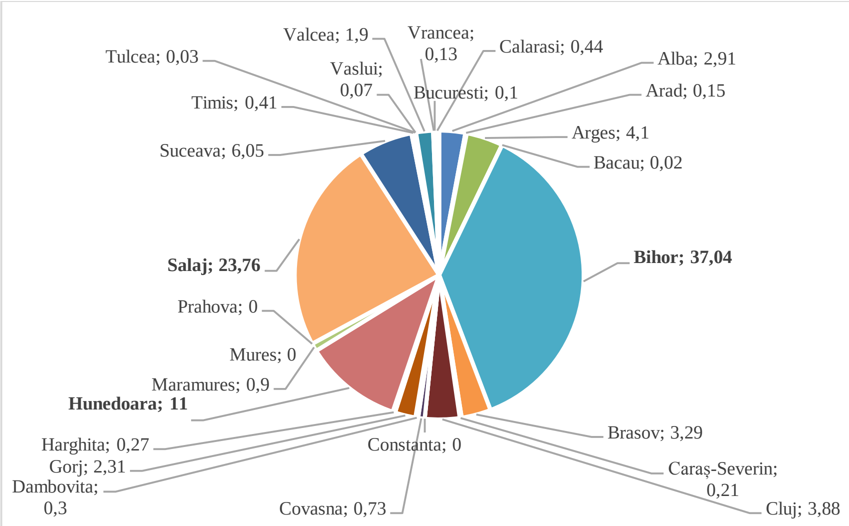


Figure 11. Share of companies' revenue by counties

Source: processed after data provided by Sectorial Study. Collection of non-wood forest products from spontaneous flora, 2020

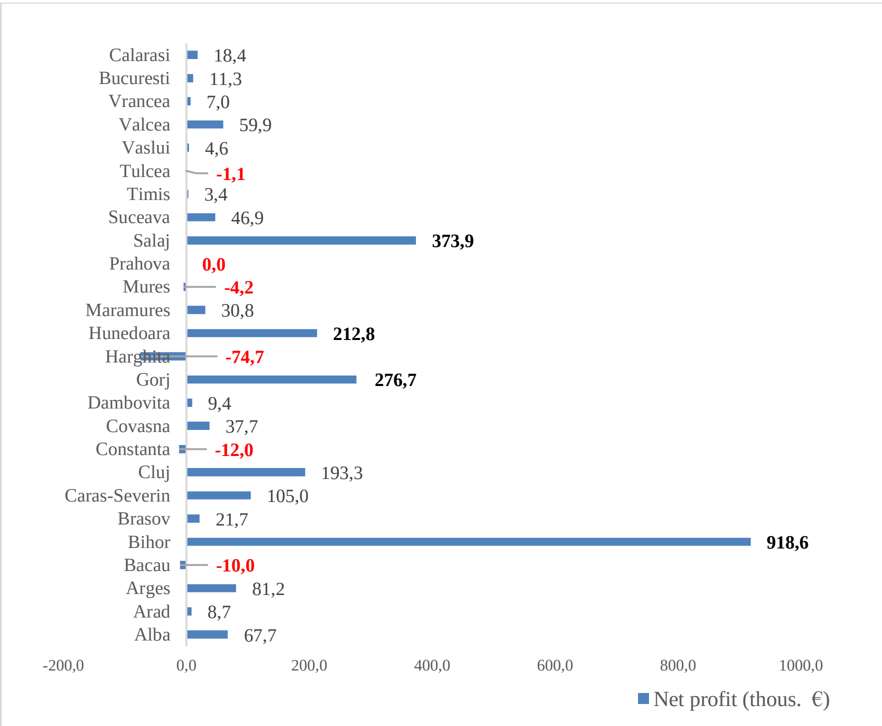


Figure 12. Companies net profit by counties

Source: processed after data provided by Sectorial Study. Collection of non-wood forest products from spontaneous flora, 2020

The companies from Arad, Bihor, Brașov, Cluj, Covasna, Gorj, Caraș-Severin, Vaslui, Vâlcea and Bucharest counties have a high capacity to pay the financial obligations in the next period, with a rating of over 7.5. The companies from most counties have a normal rating, and the companies from Harghita and Maramureș counties have a low rating (Figure 13).

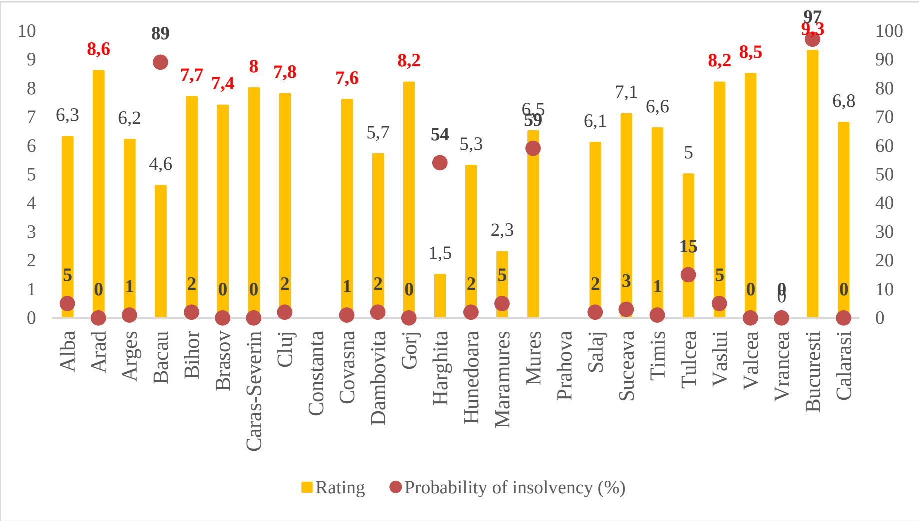


Figure 13. Rating and probability of insolvency of companies by counties

Source: processed after data provided by Sectorial Study. Collection of non-wood forest products from spontaneous flora, 2020

The probability that companies in the field of collecting non-wood forest products from spontaneous flora will not be able to pay their financial obligations to the company's creditors is very high in some counties such as Bacau, Mures, Harghita and Bucharest. A high probability indicates an increased risk for the company, but it is not a certainty that the company will go into insolvency. At the opposite pole are the businesses from Arad, Brasov, Caras-Severin, Gorj, Valcea and Vrancea counties, which have a 0% probability of insolvency.

CONCLUSIONS

At European level, non-timber forest products from spontaneous flora are part of many European households, either due to consumption or involvement in the collection process at least once a year for own consumption or sale. The collection work carried out by more than 60 million European collectors, some of them even organized in associations, has a positive impact on public health and well-being, which is quite difficult to quantify (Martinez de Arano et al 2021).

Non-wood forest products from spontaneous flora can be seen as a source of nature-based solutions not yet fully valued. Non-wood forest products from spontaneous flora can make a significant contribution to European policy in the context of the European Green Deal.

It is necessary to develop innovative and territorial value chains and "tools" to facilitate the connection between those who collect / collect and the "consumer" industry.

Some non-wood forest products from spontaneous flora can have a positive impact on the development of local tourism (mushroom picking, medicinal plants).

Non-wood forest products from spontaneous flora face identified risks and threats both globally and locally (climate change, land use, uncontrolled harvesting, inadequate management, illegal trade, competition with market alternatives). Risks amplified by lack of knowledge, resource levels (distribution, productivity), harvesting techniques, information related to production, consumption and trade. Lack of knowledge is also reflected in the lack of proper regulations and management, proper labelling, quality standards, ultimately affecting the transparency and safety of the product.

The non-wood forest products from spontaneous flora sector is interesting and challenging due to the diversity of products, but also risky because the abundance and availability of products depends to a large extent on natural factors (Novac et al 2021).

The seasonality of some products entails some “syncopes” in the process of sale, conditioning and distribution, the Romanian companies being still able to ensure constant quantities on the market.

The non-wood forest products from spontaneous flora sector in Romania is a developing sector, under the influence of natural factors and the growing interest of consumers for this type of products.

Those 88 companies that were active in Romania in 2020 in the field of collecting non-wood forest products from spontaneous flora registered a profit margin of 4.16% and an average rating of 6.1%. According to estimates, in 2022 the sector will register an increase in turnover of 6.51% compared to the previous year, and in 2023 the estimated increase is 6.12% compared to 2022.

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GREENING THE MANAGEMENT AND IMPROVING THE ENVIRONMENTAL MANAGEMENT FROM THE PERSPECTIVE OF SUSTAINABLE DEVELOPMENT

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ABSTRACT

Environmental management problems are acute imperatives that can determine the success or failure of the application of a general environmental mechanism, the solution requires the managers of swine farms, because environmental management in conditions of sustainable development is an object of study, a discipline that needs to be refined through multiple environmental risk research. In order to reduce the effects of environmental risk, integrated production management will also include environmental management oriented towards ecological exploitation, in open-air, in alternative and grazing systems and super-intensive operations in microclimate-controlled shelters, using hybrids with high conversion potential of food and which produce small amounts of manure. In order to green the integrated management of animal farms, the production programs will be oriented towards the green farm, ecologically clean, with optimal numbers, depending on the degree of environmental affordability, for sustainable development. Achieving this goal requires positioning farms in the managerial context of sustainable development, analyzing potential pollutants based on farm modeling, assessing the ecological status of the farm, implementing the environmental risk management system integrated with sustainable development management, improving the management of ecological marketing and repositioning farm reputation management within the boundaries of sustainable development.

Keywords: holdings production, environmental management, greening.

INTRODUCTION

Greening management and avoiding environmental risk involves carrying out analyzes and research in professional swine farms leading to: (Dumitriu 2002; Kotler 1997; McGlone – Pond, 2003)

- improving the integrated management of small and medium-sized professional farms with the possibility of expanding to large integrated farms for industrial meat production;
- optimizing herds and production according to market requirements;
- analysis of the degree of affordability of natural environmental factors in the vicinity of human communities;
- increasing the efficiency of exploitation by implementing the most modern technologies to ensure animal welfare;
- the expression at the optimal parameters of the biological properties of hybrids and specialized breeds for meat production;
- analysis and monitoring of environmental factors;
- introduction of environmental risk management as a component part of integrated production management (Darabonț et al., 2001; Petroman et al., 2015);
- research on technological and environmental factors that influence swine production. (Petroman 2007; Suciu et al, 2016; Voicu – Dobre, 2003).

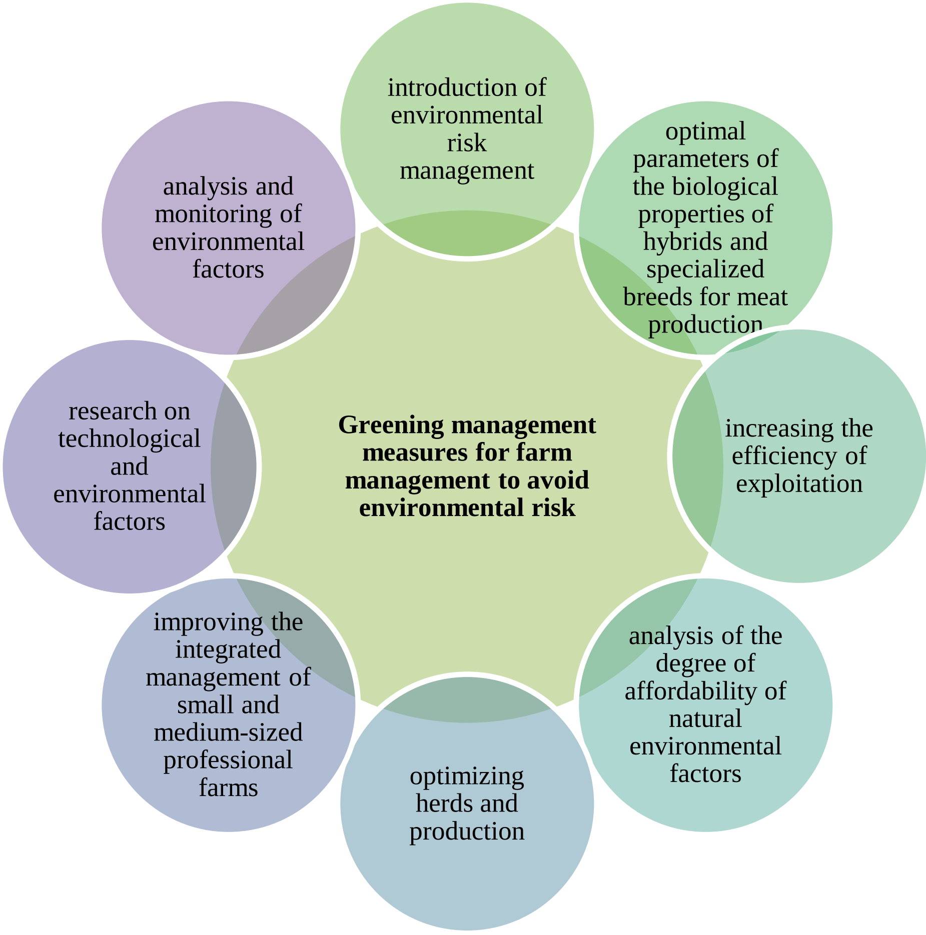

Figure 1. Greening management measures for farm management to avoid environmental risk

In order to increase meat production and avoid recourse to imports from the European Union and noneuro, research must find solutions to obtain production in traditional and alternative systems and to protect the environment in the area of farms and propose concrete measures to improve integrated production management on the entire meat production chain from (Nuthal 2010; Pantea - Gligor 2012; Petrescu 2015):

- farm biosecurity and animal welfare;
- optimization of microclimate factors and operating systems according to market requirements for carcass and meat quality;
- environmental risk management by reducing the amounts of liquid and solid manure from farms;
- farms specialization, increasing and exploitation of suckling piglets and young pigs for fattening
- optimizing the density of animals with technological indications, increasing the feed conversion rates and reducing the amount of manure;
- technological processing of manure before use as organic fertilizer;
- adapting production systems and technologies according to existing resources, the potential of the farm to control the environmental risk (Ristea et al., 2018; Rojanschi, 2002);
- the use of alternative swine production systems, the use of local resources for the sustainable development of communities from the area of swine farms and the maintenance of a healthy environment (Petroman et al., 2010; Rotaru, 2007; Shein, 2010).

Due to the fact that sustainable development management is based on principles that guide medium and long-term strategies, when created new farms, environmental and management risk must be one of the most important priorities of integrated meat production management in capacity building, classic or alternative production and operating system (Bidireac et al., 2015; Bolocan et al., 2016; Petroman – Petroman, 2006; Zahiu, 1998).

MATERIAL AND METHOD

The production systems management, in order to avoid environmental risks, must be oriented towards the production of swine meat in alternative systems with the use of local resources, for the sustainable development of the areas in the vicinity of animal farms. In this scientific approach taking into account these goals, we sought solutions for the implementation in small professional swine farms of an ecological management aimed at obtaining quality production, using local resources in compliance with environmental protection requirements and contributing to sustainable development by directing exploitation towards environmentally friendly production, using more environmentally friendly technologies.

RESULTS AND DISCUSSIONS

Sustainable development management is based on principles that guide medium- and long-term management strategies and actions in the field of swine breeding and exploitation:

- revitalization through management of the production increase, reduction of the specific consumptions, increase of the indices of food conversion in order to satisfy the needs of the agri-food market;
- management orientation towards improving the resource base, by improving the quality management and ensuring a sustainable system for the population;
- international cooperation in transactions with animals and animal products, by developing an efficient traceability system;
- the decisions elaboration for the integration of the environmental management in the integrated production management, for the prevention of the environmental risks, because the management of the sustainable development implies the following aspects:
    - a). resizing management functions in order to cope with new imposed requirements
    - b). development of capital flows and their efficient control;
    - c). specialization and qualification of human resources;
    - d). the use of quality and high-yield raw materials for reduction the amount of manure;
    - e). modern technologies for production, processing, processing of waste;
    - f). efficient management of information flow;
    - g). marketing management;
    - h). the best integrated environmental risk management of production system.

Because the environmental management presses for the reduction of the environmental risk factors, by greening the management, the introduction of the managerial processes in the essence of the ecological reality will be pursued. We believe that in this way the ecological management in the breeding and exploitation of swine with modern production technologies contributes to:

- the orientation of the joint efforts of the manager and of the entire human resource towards an ecological culture;
- uniting the scientific culture of meat production with the humanistic one regarding the protection of the ecosystems in the area of the farms;
- the sustainable eco-social evolution of the communities in the exploitation area;
- improving ecological environmental management systems, by reducing pollution;

- extension of environmental management systems according to ISO standards;
- diversification of intervention tools for environmental risk factors;
- a continuous and transparent communication, through the information flow’s management;
- monitoring the quality of the environment;
- ensuring the population health;
- directing the rational use of resources and their conversion into safe products.

We consider that the implementation of this type of management, that is, the ecological management oriented on obtaining quality productions, in accordance with the total quality management and the protection of the environment, will contribute to the sustainable development by:
- use of resources according to market requirements and consumer needs;
- directing efforts towards ecological productions;
- implementation of environmentally friendly technologies;
- correcting the proposed goals according to the quality conditions of the environmental factors;
- adapting the productions to their degree of tolerability of the natural environmental factors.

In order to reduce the effects of environmental risk, integrated production management, which includes environmental management in any holding, must be oriented towards ecological, open-air, alternative and pasture exploitation and super-intensive farms in microclimate-controlled shelters, using hybrids with high potential for food conversion and producing small amounts of manure.

We consider that the integrated management of the farms must be oriented towards the green farm, ecologically clean, with optimal numbers calculated according to the degree of environmental tolerability, for the sustainable development of the area in the vicinity of the farms. To achieve this goal it is necessary:
- positioning farms in the managerial context of sustainable development;
- analysis of the polluting potential depending on the modeling of the farm herds;
- assessment of the ecological status of the holding;
- implementation of the environmental risk management system integrated with the sustainable development management;
- improving the management of ecological marketing;
- repositioning the management of the farm's reputation within the boundaries of sustainable development.

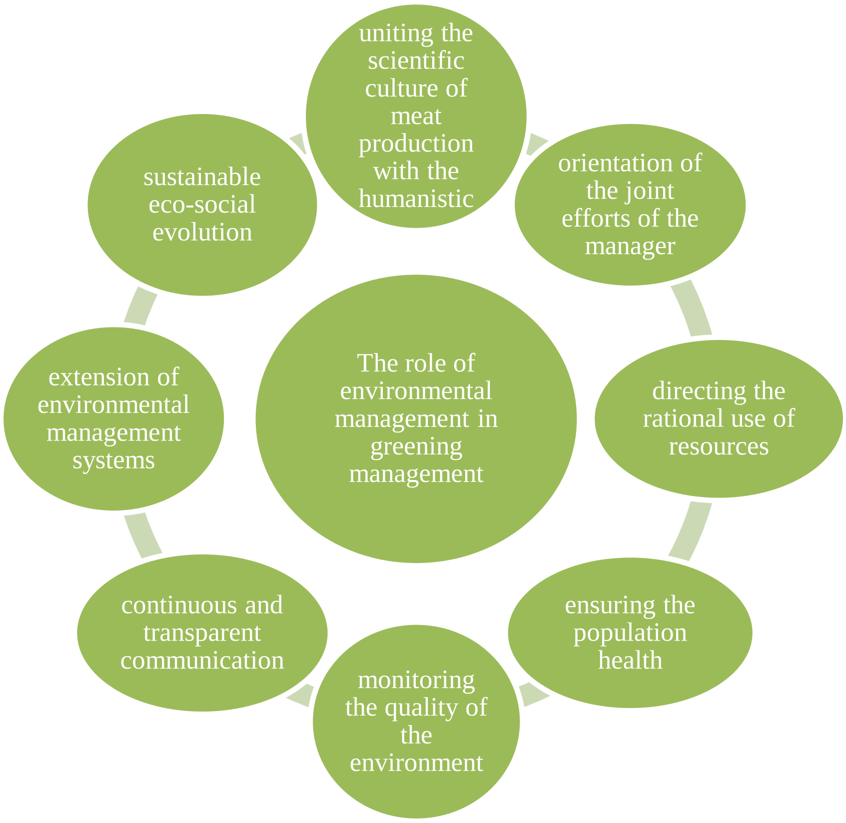

Figure 2. The role of environmental management in greening management

In order to maintain the quality parameters of the environment and to avoid pollution in the areas in the vicinity of the farms, we propose for the small professional farms to implement preventive measures that will contribute to:

a. farm biosecurity;
b. maintaining a clean and unpolluted environment;
c. maintaining the health of human communities;
d. their sustainable development.

Measures necessary to be promoted to maintain a healthy environment include:

- programs aimed at protecting and restoring environmental factors degraded by pollution;
- coordinating the programs of qualified persons;
- identification of pollutants with effects on environmental factors;
- measures for reducing the noxious substances through the production technologies implemented by the integrated management;
- information and training of human resources on environmental quality;
- periodic control;
- elaboration of performance reports.

These measures taken in small professional holdings, regardless of the operating system implemented and the manure management technology must be limited to the evaluation of the following aspects:

a) the negative effects of production on the environment;
b) the farm's pollution prevention options;
c) the means and technologies used to avoid environmental risks;
d) the possibilities to carry out the control over the environmental protection activity against pollution of any kind, physical, chemical, biological or natural.

Through proper forecasting, planning, coordination, command and control, preventive environmental management can contribute to greening environmental management by:

- reducing the pollution of environmental factors;
- reducing the risks of pollution by implementing the best management;
- economic growth of production activity by implementing integrated management and cost reduction;
- conservation of floristic and faunal ecosystems;
- preserving biodiversity.

CONCLUSIONS

Sustainable development management is based on principles that guide medium and long-term strategies as well as managerial actions in the field of farm animal husbandry and exploitation, by revitalizing production growth through management, its orientation towards improving the resource base and efficient management of liquid manure and solid, international cooperation in transactions with animals and animal products, by developing an efficient traceability system and developing decisions to integrate environmental management into integrated production management, to prevent environmental risks. It is considered that environmental management advocates reducing environmental risk factors and by greening management, will aim to introduce managerial processes in the essence of ecological reality contributing to the efforts of those involved in this activity towards an ecological culture, the union of scientific and human sustainable eco-social evolution of communities. In order to avoid pollution of areas in the vicinity of production units and to maintain environmental quality parameters, sustainable development of communities, preventive measures are needed to help ensure biosecurity of farms, maintain a clean and unpolluted environment and maintain the health of animals and communities from the farm area.

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MEASURES TO REDUCE LIQUID AND GROUNDWATER POLLUTION FROM THE AREA OF PROFESSIONAL SWINE FARMS

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ABSTRACT

The main pollutants of surface and groundwater can also be liquid manure from swine farms, if their treatment is not done properly and accidentally end up in the emission, helping to reduce the amount of dissolved oxygen, with undesirable effects on aquatic ecosystems. Pollution of water sources is done in three ways, physical, chemical and biological, the ecological effects manifesting themselves by changing abiotic factors and implicitly all trophic levels. Untreated discharges, untreated in low-flow outflows, such as most rivers in the analyzed area, Timis County, during the summer, manure contributes to water heating and decreases the degree of oxygenation caused by accelerating the decomposition of organic mass. These effects are also visible in the area of former sewage treatment plants belonging to disused farms, where the waters in the area due to the activity of aerobic microorganisms, flourished and some species of fauna and flora disappeared even if the manure evacuated, after a certain processing discharge they had 50 milligrams per liter of CBO5 at their disposal. The greatest pollution of groundwater is also caused by nitrogen from liquid manure from swine, by infiltration into the soil because the quantities of manure administered to increase agricultural production are not properly controlled and managed, appearing in areas of serious environmental risk.

Keywords: swine, farms, manure, pollution

INTRODUCTION

Swine farms are production units equipped with accommodation, utility annexes and specific means of transport, in which the production process is provided by managers, specialists in the field and skilled labor force. Farms must be located in areas authorized by environmental bodies and, in addition to the fenced enclosure, may also have land areas intended for plant production (Ianculescu & all 2002; Iuga 2007). The mechanism of operation of the management system is based in the case of swine farms on a set of: laws, principles, methods and procedures that make up its methodological elements. The technical-social organization of swine production takes place in the conditions of a great diversity of forms and types of farms, which can be classified according to the form of ownership, production orientation, nature of activity, integration criteria and technical-economic profile. Bogdan & Comşa 2011; Cândea & all 2006; Dumescu 2006; Gruia 1998).

The establishment of a professional swine farm, from a managerial point of view, requires investments in land acquisition, funds for the construction of shelters, investments in exploitation technology; automation of the main farm activities, ensuring the microclimate, feeding the animals, providing water, providing energy, construction of modern wastewater treatment plants to avoid environmental risk, investments in management and human resource qualification and development of procedures on environmental management and implementation of the best management. In order to make an investment regardless of the size of the professional swine farm, it is necessary to know some elements that, condition the viability and economic efficiency of the farm, or negatively influence the development of the production process. For these reasons, in order to set up a swine farm, it is necessary to go through several stages (Ionescu & Cazan 2005; Iordache & Ardelean 2007):

- ❖ knowledge of all geo-climatic and economic factors in the area of the production unit;
- ❖ establishing the location: water source, electricity network, road network, the possibility to efficiently use manure and wastewater to increase agricultural production;
- ❖ elaboration of the technological engineering project;
- ❖ elaboration of the technical-economic study;
- ❖ elaboration of the execution project;
- ❖ execution of constructions and utilities;
- ❖ equipping the farm with the most advanced equipment;
- ❖ animal population;
- ❖ implementation of farm management.

The choice of the geographical area and the location of the holding is an important decision, given that once the animal shelters have been built, they cannot be moved to another location may influence the evolution of the holding, depending on the location: (Anghelache 2010; Băbuţ & Moraru 2002)

The most important technical factors are the following: (Bolocan & All 2015a, 2015b, 2015c)

- Elimination of the pollution risk by optimizing the size of the farm and the systems of collection, treatment and disposal of manure;
- Climate from the exploitation area. Among the climatic factors, we will analyze the minimum and maximum air temperature, day and night, on months and seasons and the relative humidity that provides information on the humidity that is recorded in the atmosphere at different times of the year. The wind is an important component of the climate, depending on the prevailing winds are established:
    - the location of the swine shelters;
    - the thickness of the shelter walls;
    - the need to set up protective curtains around the holding.
- The soil must be stable, not swampy, and not in the vicinity of outfalls that could flood the farm.
- Drinking water is an important factor in the location of the swine farm because:
    - ensures the needs of animals and human and technological consumption;
    - be sufficient in quantity and within drinking limits;
    - must be located at great depths to avoid contamination of the groundwater;
- Another important factor in the location of swine farms is the rainfall regime;
- The fodder resources must be known before the location of the swine farm, being established according to the size of the farm where they will be procured: own production, purchases.
- The energy source is represented by the electricity network and its own power generators in case of failure.
- Road and rail transport routes must pass close to the holding to ensure efficient feeding and the population and depopulation of animals.

The economic factors that determine the location of swine farms are the consumption of meat in the area, the consumption trends, and the sources of meat and meat products in the area and the possibilities of marketing (Baron 2001; Văduva 2013).

From the research conducted over time, it turns out that in the area of swine farms and not only, the values of nitrogen in surface and deep water are different depending on the source of the pollutant, but reach high levels in emissions near livestock farms when manure is administered as organic fertilizer in large quantities to increase production and are not properly processed by separation and the resulting liquids were discharged into the emissaries. This is no longer the case today with modern processing and management technologies by incorporating manure into controlled dilutions to reduce their negative effects on environmental factors (Petroman & all 2013; Wiseman & all 2003).

Agriculture in general and animal husbandry in particular are one of the main sources of pollution of surface and deep water, being considered the greatest enemies of human health and the environment. Pollution with nitrates, nitrites, phosphates and other harmful substances is considered the main cause of the change in the quality of water resources, with major effects on human health and the environment (McGlone & Pond 2003; Nicholson 1994; Petroman & Petroman 2006).

MATERIAL AND METHOD

In order to determine the negative effects of pollution sources, manure from swine farms, as part of this scientific approach, analyzes were performed on the evolution of groundwater composition by taking samples from control drilling, from water treatment plants used before being incorporated into the soil, administered as organic fertilizers to increase crop production. The monitoring of groundwater quality indicators was carried out by laboratory analyzes, every six months at the control drilling from the area of the manure storage and annually on the soils where these controlled manure was incorporated to increase plant production.

RESULTS AND DISCUSSIONS

The quality parameters of the surface water from the area under investigation at the control drillings, for a period of three years are presented in the following tables.

Table 1. Groundwater quality indicators at P1 drilling from manure storage area

		2019		2020		2021	
Item	UM	First Semester	Second Semester	First Semester	Second Semester	First Semester	Second Semester
Water pH	pH	7.35	7.45	7.20	7.47	7.10	7.50
CCOMn	mg O2 / liter	6.34	4.48	2.10	5.65	1.97	3.10
NH4 +	mg / liter	0.20	0.13	0.18	0.10	0.20	0.31
nitrites	mg / liter	0.49	0.37	0.40	0.20	0.04	0.17
nitrates	mg / liter	2.45	2.18	0.34	2.40	0.60	1.43
total phosphorus	mg / liter	0.02	0.04	0.15	0.08	0.13	0.45
chloride	mg / liter	9.30	37.80	22.67	11.90	20.22	31.14

Table 2. Groundwater quality indicators for P2 drilling on land fertilized with liquid manure

		2019		2020		2021	
Item	UM	First Semester	Second Semester	First Semester	Second Semester	First Semester	Second Semester
Water pH	pH	7.20	7.00	7.30	7.80	7.50	7.70
CCOMn	mg O2 / liter	3.44	4.60	1.70	1.85	1.80	1.97
NH4 +	mg / liter	0.50	0.33	0.22	0.30	0.10	0.77
nitrites	mg / liter	0.50	2.70	0.30	0.16	0.44	0.14
nitrates	mg / liter	3.45	0.78	2.34	0.40	0.70	0.33
total phosphorus	mg / liter	0.07	0.05	0.09	0.16	0.13	0.35
chloride	mg / liter	10.20	17.10	14.67	21.40	18.42	24.16

Table 3. Groundwater quality indicators for P3drilling on land fertilized with liquid manure

		2019		2020		2021	
Item	UM	First Semester	Second Semester	First Semester	Second Semester	First Semester	Second Semester
Water pH	pH	7.40	7.10	7.20	7.50	7.40	7.30
CCOMn	mg O2 / liter	12.44	12.00	1.80	1.55	1.60	1.45
NH4 +	mg / liter	0.40	0.23	0.02	0.04	0.03	0.31
nitrites	mg / liter	0.04	1.70	0.07	0.03	0.04	0.22
nitrates	mg / liter	1.37	0.60	2.84	3.60	0.50	0.09
total phosphorus	mg / liter	0.005	0.005	0.08	0.26	0.18	0.46
chloride	mg / liter	100.80	37.40	24.90	19.70	16.60	14.23

Table 4. Groundwater quality indicators for P4drilling on land fertilized with liquid manure

		2019		2020		2021	
Item	UM	First Semester	Second Semester	First Semester	Second Semester	First Semester	Second Semester
Water pH	pH	7.10	7.70	7.20	7.60	7.10	7.20
CCOMn	mg O2 / liter	1.79	2.92	2.83	3.12	1.70	1.95
NH4 +	mg / liter	0.50	0.28	0.15	1.44	0.63	0.81

nitrites	mg / liter	0.44	2.50	0.17	0.07	0.44	1.31
nitrates	mg / liter	0.37	0.60	12.84	4.90	0.56	0.02
total phosphorus	mg / liter	0.03	0.06	0.08	0.12	0.13	0.24
chloride	mg / liter	5.80	7.40	14.80	27.40	15.50	22.13

The nitrate limits from the 3 control drillings, drilling 1 being the reference, analyzed during the study period, show the influence of fertilizers from liquid manure from the swinefarm, on groundwater, and are presented in the table 5.

Table 5. Average values of nitrates in control drills

Drilling type	Analyzed indicator	UM	Determined value	
			First Semester mg/l	Second Semester mg/l
Manure storage tanks	nitrate	mg/l	0.34- 0.60	1.43-2.40
Control drilling P2			0.70-3.45	0.33-0.78
Control drilling P3			0.50-2.84	0.09-3.60
Control drilling P4			0.37-12.84	0.02-4.90

It is found that both for the determinations made during first semester and for those performed in second semester, for all 3 years the permissible limits of pollution have not been exceeded. The locality where the swine farm is located is found in the list of locations where there are sources of nitrates from agricultural activities, being included in "vulnerable and potentially vulnerable areas."

We believe that the increases in nitrates during the analyzed period are also due to the weather conditions, because the amount of precipitation was high in the three years analyzed and led to increases in concentrations in groundwater that are not at great depths. The soil being permeable and with low water retention capacity favored the pollution of groundwater with nitrates.

Research has shown that the concentration of swine farms in some areas of Timis County has led to deterioration of groundwater and surface water quality, the causes being multiple

- the high density of swine in relation to the existing lands in the farms area;
- the positioning of some swine farms on sloping lands that determine the water leaks;
- faulty way of handling solid manure, quantities are not controlled;
- excessive use of solid swine manure over the years, leading to massive accumulations of nitrates in the soil, respectively groundwater;
- the use of swine watering technologies where water waste is high;
- the discharge of hydraulic manure has resulted in obtaining excessive amounts of manure that have not been properly managed causing pollution of surface and groundwater.

In order to reduce the negative effects on water resources, we propose to implement the following managerial measures to reduce surface water pollution:

➢ Development of good practice codes in the use of solid or liquid manure as organic fertilizers to stimulate plant production:

• establishing the period of integration of liquid manure in the soil;
• establishing the maximum quantities of solid manure for increasing plant production;

• use of swine manure depending on the degree of soil quality, its composition, texture;
• giving up the use of liquid manure as fertilizer on soils in the vicinity of watercourses;

- use of modern manure storage methods:

• construction of watertight storage tanks;
• concreting solid manure storage platforms;
• reducing the infiltration of slurry into the soil,
• reduction of groundwater pollution by reducing the amount of manure, exploiting species that produce smaller amounts of manure;

- increasing manure storage capacity:

• by monitoring the staff according to the storage capacities;
• production growth prospects;

- improving the transport conditions from the farm to the manure storage depot;

• waterproof transport logistics, waterproof;
• modern pumping, storage, processing techniques;
• constant analysis of manure qualities.

- modern agrotechnical technologies in the area of farms:

• cultivation of plants that restore the soil structure;
• cultivation of plants that maintain soil quality;
• soil rotation for fertilization with manure;
• modern methods of dilution, incorporation and spreading of manure on/in the soil;
• reducing the risk of nitrate pollution of groundwater, by:
a. the controlled application after analysis of the fertilizers on the lands inclined towards emissaries;
b. with a low degree of water permeability.

- efficient management of lands with environmental risk, through:

• analysis of the amount of nitrates in the soil by mapping;
• GIS fertilization;
• differentiated fertilization of soils depending on the nitrate load;
• establishing the optimal nitrogen and phosphorus requirements depending on the soil quality and the degree of tolerability;
• control of the quantity and quality of manure water;
• application of solid manure to the soil as a fertilizer to increase production;
• use of the best method of irrigation with diluted manure, depending on soil permeability, water retention capacity, type of crop, period;
• analysis of the amounts of nitrates, which can be processed by the plants used in the previous crop and the reserves that are still in the soil.

- monitoring environmental factors, following their evolution over time and their effects:

• air quality indicators (ammonia, hydrogen sulfide);
• quality indicators of manure distributed on agricultural land;
• protection of surface waters against nitrate pollution;
• groundwater quality indicators by physico-chemical determinations from samples from monitoring boreholes;
• soil quality indicators;

- implementation of the best management to improve the management of environmental risk.
- improving the management of information flow.

CONCLUSIONS

For the determinations made in the researched area, it is found that the permissible limits of pollution have not been exceeded, although the localities in the vicinity of farms are found in locations where there are sources of nitrate from agricultural activities, being included in "vulnerable and potentially vulnerable areas." We consider that the increases of nitrates in the analyzed period are also due to the weather conditions, because the amount of precipitation was high in the three years analyzed and led to increases in concentrations in groundwater that are not at great depths and the soil is permeable and low capacity of water retention. In order to reduce the negative effects on water resources, it is necessary to implement at the level of swine farms measures to reduce surface water pollution by developing codes of good practice in the use of solid or liquid manure, monitoring environmental factors, implementing the best management for improving the environmental risk and improving the flow of information on the quality of the natural environment in the area of swine farms.

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IMPLEMENTATION OF NEW ENVIRONMENTAL RISK MANAGEMENT PROGRAMS IN PROFESSIONAL ANIMAL FARMS

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ABSTRACT

The new environmental risk management programs must provide for a longer period of time projects and activities planned and implemented, in order to achieve the risk management options that may occur in the production activity of the holding. In order to be effective, these programs must include in the budgets established at farm level, the costs related to the development and implementation of environmental programs, the responsibilities of the management team and environmental risk specialists, the deadlines for implementation according to the objectives set and approval of programs and their funding line. Environmental risk management programs must identify at farm level the role of integrated risk management, the responsibilities of the manager and the persons designated in environmental risk management, how to act on risk factors and the implementation of measures set as objectives for effective environmental risk management and adherence to integrated management.

Keywords: farms, management, environmental risk, integrative management

INTRODUCTION

The environment, ecological and living environment is a set of physical, chemical, meteorological, biological factors from an area, with which an organism comes into contact. The environment influences organisms, which in turn, including humans, change the environment because the adaptation to environmental factors is limited. It is known that ecological balance relations are established between the ecological communities of a biome, but this balance can be modified under the action of artificial and natural factors (Andriciuc 2008; Căpeț et al. 2021; Bolocan et al. 2016). When man intervenes in the evolution of ecosystems, by changing the factors, especially the quality of water, soil and air, there is environmental pollution with effects on animal and human health by degrading resources, ecosystems and material property (Gruia 2013; Ionescu - Cazan 2005). In this way the pollution can be:

- Artificial pollution, which depending on the nature of the pollutant can be physical pollution, chemical pollution and biological pollution.
- Natural pollution, produced by manure from animals that are not properly managed and end up in large quantities unprocessed in surface waters, groundwater by infiltration, soil and air as gases resulting from their fermentation, having adverse effects on the environment and of human health.

Also the volume of pollutants that have effects on the environment and implicitly on human health and their intensity is directly proportional to the need for raw materials demanded by consumers on the market. In this way the pollution degree increases exponentially through the action of new pollutants that are in quantities higher than the degree of environmental tolerability, but the effects are not immediate but are combined over time, for these reasons it is found that (Petroman et al. 2010; Popescu - Dobre 2000; Xiao - Wen 2013):

- from the entry into action of new pollutants in larger quantities to the recording of environmental effects, a fairly long period of time passes;

- there is an interval between the polluting action on the environment and the finding of the effects of water, soil and even air pollution in the vicinity of animal farms;
- the effects of pollution are minimized because the degradation of the environment is done in a long period of time, especially for groundwater due to the slow infiltration of wastewater into heavy or clayey soils, the effects being found after many years.

The impact of human anthropogenic action on the environment in the area of some farms, some disused today materialize in time through (Heber et al. 2010; Shein 2010):

- change in the composition of surface waters, by accidental discharges or above the limits of admission of emissions in periods of drought when river flows were low;
- change in soil composition, accidentally or intentionally fertilized with quantities above the limits of tolerability;
- change in the composition of the atmosphere, due to gaseous products from fermentation;
- modification of some areas from the perimeter of some wastewater treatment plants;
- transformations in the structure of the vegetal cover, due to the administration of large quantities of manure, which does not degrade until the second year of administration, being a cold fertilizer, produced changes in soil texture and the appearance of invasive plants, changing the floristic composition of grasslands, soils become acidic, today there is a need to implement measures for their ecological rehabilitation, restoration of structure, texture and increase their productive value (Nicholson 1994; Petroman et al. 2010);
- changing the structure of aquatic, floristic and faunal ecosystems, by the disappearance of some fish and crustacean species, the disappearance of some plant species and the migration of some animal species of hunting interest to other areas less affected by the effects of pollution or even their disappearance by habitat loss especially during the breeding and rearing of chicks by flooding the land, due to clogging of manure channels, lack of quality water and last but not least quality food due to the fact that some lands have become arid, due to lack of proper management to provide environmental risks (Nuthal 2010; Petrescu 2015; Petroman et al. 2019);
- the decrease of the degree of adaptability of some plants and animals, due to the alteration of their genetic background and the decrease of the capacity to adapt, reproduce and restore the herds to the limits that do not endanger their existence (Adzig et al. 2018; Gruia 2006).

The current trends in the development of management systems are in nature to bring quality management closer to environmental management and the management of safety and security at work and human resources, at the level of animal farms. It is necessary to implement an integrated quality management system with environmental protection that takes into account all the conditions related to health and safety regarding the protection of production systems, human resources, products obtained and distributed on the market, the environment of the farm area and consumers of agri-food products (Kotler 2003; Layard - Glaister 2003; Ristea et al. 2018).

MATERIAL AND METHOD

The stated aim of the research carried out in the area of professional animal farms was to be able to draw relevant conclusions on: measures to be taken at farm level to reduce accidental pollution of environmental factors and to propose measures to reduce the risk of environment for both the community and the farms in Timis County. In this regard, the environmental management system will allow a more efficient management of the problems faced by the farm, the framework for solving priority problems will be created, the entire environmental protection activity can be effectively monitored, an action plan can be drawn up by activities and in this way the objectives proposed by the action plans undertaken can be pursued.

RESULTS AND DISCUSSIONS

The objectives set for environmental risks and the deadlines for their achievement must be clear, so that they can be verified, to the extent that they have been achieved, with a view to:

- reducing the risks that can affect the environment in the area of professional animal farms;
- improving environmental risk management systems;
- improving risk prevention procedures
- the use of logistics for the analysis of environmental factors in the exploited area;
- specialization of persons involved in environmental issues, according to the new guidelines on environmental risk management;
- making the entire human resource responsible for the issues related to environmental protection;
- preparation and training of human resources to deal with emergencies.

The programs proposed for implementation must be integrated into a structured environmental management program that will be integrated into production management for efficient risk management. We believe that these risk management programs should identify the following issues at the farm level:

- the role of integrated management in risk prevention;
- the responsibilities of the manager and of the persons designated in the management of the environmental risks;
- mode of action on risk factors;
- implementation of the measures established as objectives, for the efficient management of the environmental risks.
- In order to be successful in the management act, we consider that for the professional swine farms, regardless of the exploitation systems and the implemented technologies, an integronic approach is needed, which combines various sciences, concepts, resources and facilities in the realization of risk management environmental programs. Integronics in modern management systems is gradually found at different levels characterizing:
    - managerial components by levels;
    - distinct managerial components;
    - complementary degrees of integration.

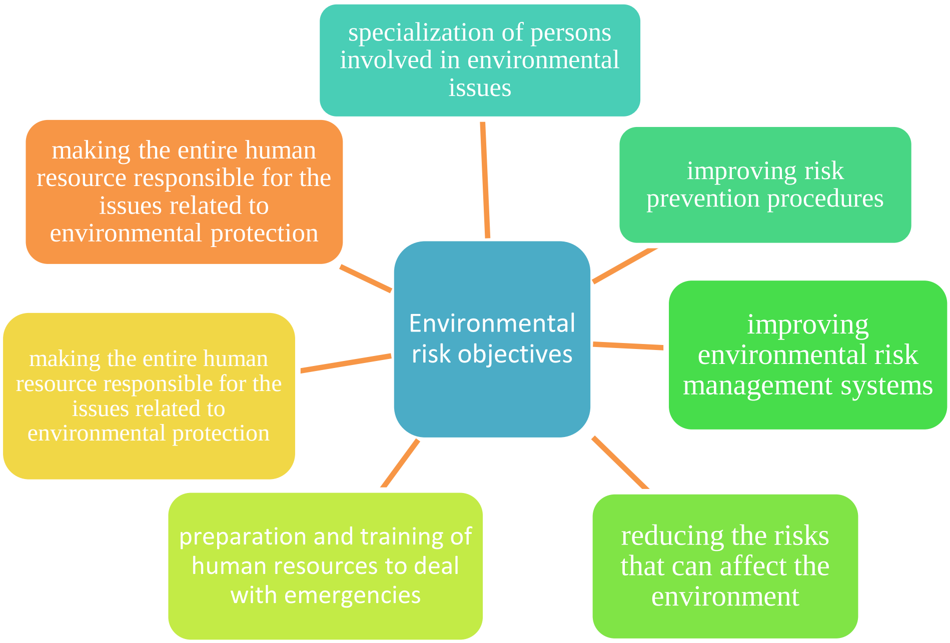

Figure 1. Environmental risk objectives

Integrated management at the level of professional holdings, regardless of the operating system, will include:

- level I - intrinsic integration of production management, financial management of the farm, human resources management, manure management, marketing management - in a word the classic organizational management, at farm level, in conditions of increased economic efficiency;
- level II - integration in the business environment and in the natural environment from farms the area, of ecofarm management, agrotourism management, ecotourism management in economy-environment management;
- level III- integration in nature, resource management, restoration management of the degraded environment, management of the capacity to restore the quality of soil, water, air - ecological management;
- level IV- integration in the model of the metabolic society, management of competition between biological material used in production, management of competition between omnivorous and meat-producing ruminants, management of transition to a higher level of organization, performance - biological-informational management.

We consider that integronic management goes beyond the classic organizational management, in terms of the general approach to the problems of integrated production management and environmental risk management in professional animal farms, in terms of addressing the following general issues at the ecosystem level or economy-environment system:

• integration of the animal farm in the competitive environment;
• integration of the farm in the communities in the product distribution area;
• integration of the holding in the environment.

As secondary objectives at the level of professional holdings, generated by the integronic management are the following:

✓ at system level, actions aimed at the ecosystem in the area of farms, landscape or landscape management - in order to stop the process of environmental degradation and accumulation of resources:

a. organic matter from manure, which used rationally will contribute to increasing plant production and restoring soil texture;

b. regulating the balance regarding the water and air quality in the exploitation area;
c. avoidance of soil and water pollution with nitrates and heavy metals, by processing manure before incorporation into the soil;
d. monitoring ecological and biological processes;
e. designing and proposing programs for biodiversity conservation;
f. improving environmental risk management by designing programs.

✓ implementation of new programs for obtaining organic production, improving marketing management and increasing economic efficiency by moving from integrated production management, quality, human resources and environmental risk to integrated management by developing new specific methodologies for evaluating:

a. complex environment-economy systems;
b. plant and fauna ecosystems in the area of farms;
c. sustainability of investments regarding environmental risk management;
d. the sustainability of the basic production obtained on the farm and the degree of sustainable development of human communities in the area of holdings;
e. the transition from efficiency to operational efficiency, while maintaining an environment with healthy ecosystems.

The targets to be achieved, for sustainable development, through the environmental risk management strategies implemented by professional holdings, regardless of their size, regarding the integrated management will have to aim at:

• sustainable development through:
a) balance between maintaining the quality of the environment and the economy;
b) achieving an efficient market for meat and processed products from farm raw materials;
c) supporting and raising the level of efficiency of the exploitation, processing and distribution of products.

• environmental protection, based on the environment and energy through the following:
a) use of green energy;
b) protection of environmental factors, reconstruction through projects to restore degraded areas of anthropogenic activities;
c) ecosystem restoration;
d) evaluations by eco-energy analysis.

• implementation of new production technologies, based on projects that use renewable energy, exploitation for obtaining raw materials in alternative, ecological systems:
a) use of biotechnology;
b) the use of bioengineering in the production of production equipment;
c) the use of integrated technologies in production management, quality management, human resources management, human resources management environmental risk;
d) use of integronic management concepts for growth of effectiveness of animal exploitation and the protection of the environment.

• implementation of the most effective integrated policies, based on cooperation on all levels of the internal and external environment of farms by:
a) scientific, technological and professional cooperation;
b) systemic policies;
c) sustainable regional policies at local and regional level;
d) Euroregional politicians;

e) sustainable national and international conservation environment policies

These strategies for sustainable development and maintaining a healthy environment can be proposed for implementation on the following levels:

- farm - business environment - natural environment;
- ecological agriculture - food products (food) - rural area;
- agriculture - urban environment - industrial environment.

We can conclude that the strategies that use the concept of integronic management, are based on the ability to combine economic and ecological concepts, such as energy, ecology or economy and the multiple facilities and resources at the level of systems such as economy-environment, anthropized ecosystem, all for obtaining processed agri-food products, in conditions of efficiency and in stable balance with the environment.

Consultation and communication in environmental risk management must take into account a number of elements, when aiming to improve communication or the involvement of communities in the area of holdings in making decisions related to environmental risk:

- the use of an efficient communication in both directions manager-local community;
- trust and credibility in exposing environmental issues;
- technical and scientific competence;
- training and accountability in environmental risk management;
- high expectations;
- irreconciling different points of view;
- strengthening communities' confidence in environmental decision-making;
- assuring communities of real or perceived risks;
- environmental impact assessment by monitoring.

Using of risk analysis as a tool to improve environmental risk management aims to establish the impact produced by animal farms on the environment, becoming a method that allows:

- comparing the probabilities of impacts;
- assessment of an unknown future impact and includes uncertainty in the assessment;
- adopting risk analysis as a working method, instead of standards based on consequences.

Implemented in animal farms, the environmental risk management system in integrated management has the following benefits:

- provides a systemic framework for the identification, assessment and effective risks management;
- ensures a minimization of the holding's exposure to risks;
- increases the probability of obtaining production safely;
- facilitates the easy obtaining of environmental permits and permits;
- contributes to the proposal for implementation of new projects, action plans in case of risk situation;
- allows periodic risk assessment;
- ensures a high flexibility of action;
- identifies the most effective opportunities;
- ensures the observance of the maximum admissible limits of the pollutants;
- highlights the maximum capacity of pollutants assimilation by the environment;
- ensures a good communication with the internal and external environment;
- contributes to the improvement of the information flow management;
- ensures the preservation of the environmental biodiversity.

Environmental risk management cannot function effectively if it is not integrated into the other management systems of the holding, and the principles of sustainable development and integrated management in swine holdings cannot be implemented.

CONCLUSIONS

Human intervention on ecosystems produces changes in environmental factors with effects on human and animal health through degradation of resources and material property, through physical, chemical, biological pollution in a word artificial pollution but also due to natural pollution caused by organic matter from animals and inadequately managed. The impact of human anthropogenic action on the environment in the researched area, materialized over time, by changing the composition of surface water, soil and atmosphere but also by changing some areas within the perimeter of animal farms, for these reasons are required management programs for environment risk.

For the success of the managerial act, the production systems must approach integronic the creation of environmental risk management programs, because this form of management implemented at the level of professional holdings will include the intrinsic integration of financial production management, human resources and manure marketing management in the classic organizational management in conditions of economic efficiency. It is recommended the integration in the business environment and the natural environment in the area of farms, ecofarm management and ecotourism management in economy-environment management as well as the integration in nature of the management of resources to restore degraded environment, soil, water and air quality in ecological management. It is also recommended to increase the efficiency of exploitation and protection of ecosystems, the integration in the model of the metabolic society of the management of competition between omnivorous and ruminant species in biological-informational management. It follows that integrated management goes beyond classical organizational management in terms of the general approach to the problems of integrated production management and environmental risk management in professional animal farms in terms of how to approach general problems at the level of economic system-environment. The goals to be achieved for sustainable development through environmental risk management strategies must be aimed at sustainable development, environmental protection, the implementation of new production technologies and the most effective integrated policies at all levels of the internal and external environment of professional animal farms.

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COMPARATIVE EVALUATION OF THE AQUACROP AND HYDRUS 1D MODELS AT GÖDÖLLŐ, HUNGARY

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ABSTRACT

Climate change and other anthropogenic (agriculture, urbanization and industrialization for example) effects are causing an increase of water consumption, resulting in an increase of demand for a proper monitoring of water availability. Soil moisture is a key component that can be quite relevant for a monitoring scheme as soil moisture is important for the local energy balance, necessary for different agricultural applications, irrigation and other aspects. In places with scarce data or the inability of direct monitoring of soil moisture, mathematical models can be used to estimate the soil moisture values. This paper focuses on comparing the results of two of these models (AquaCrop and Hydrus 1D) and their advantages. The AquaCrop model focuses on crop yield and production and is mainly used for agricultural areas. Hydrus 1D model focuses on the water flown and solute transport in a specific media, being able to be used in many different situations. These models were utilized in a research site in Gödöllő, Hungary and their results were compared to the ones of a monitoring station at the research site. The applicability of these two models for soil moisture modeling were already proven by many different researchers, the current study discusses results and their applicability.

Keywords*:* soil moisture, modeling, AquaCrop, Hydrus 1D, monitoring

INTRODUCTION

Water management has become a critical issue for human well-being (Cosgrove & Rijsberman 2000) as it is important for agriculture (crop production), economic activity, and sustainable development (Vorosmarty et al. 2000). Water is a renewable resource, but as a cause of uneven distribution and increase of human population, the demand for water has continuously increased (Cosgrove & Rijsberman 2000; Bennett 2000). From 1960 to 1997, worldwide freshwater availability per capita has been reduced by 60% and the projection has concluded a decrease by 50% by 2025 (Hinrichsen 1998) and studies show that water use has raised six times over the past 100 years (Wada et al. 2016). Using AQUASTAT, a study has con-firmed the growing rate is about 1% per year (UNWWDR 2018) and other studies show that by 2050 it is projected to increase by 20%-30% (Burek 2016). Water issues have then become among the top risk in the coming decade and have become one of the most important goals on the Sustainable Development Goals (SIWI 2016; UNWWDR 2018), which this situation will lead to an economic development and security risk (UNWWDR 2018).

Soil moisture is a key component of the hydrologic cycle, which is extremely variable and nonlinear in place and time (Heathman 2012), and it regulates interactions between the land sur-face and atmospheric processes (Brubaker & Entekhabi 1996). Undoubtedly, soil moisture influences how an eco-system responds to its physical surroundings by influencing the surface energy budget and the partitioning of rainfall into runoff or infiltration (Joshi et al. 2011).

Soil moisture is subject to different spatiotemporal variations such as diversity of altitude; topography; climate and human interactions (Yang et al. 2019). Besides those variations there are others which can affect soil moisture, and are usually the ones taken into consideration for modeling, being them: soil properties, climate and vegetation cover (Fay et al. 2003).

AquaCrop, a model developed by the Food and Agriculture Organization of the United Nations, is one of several different models that aid water management related to crop production. AquaCrop is a general model for a large range of agricultural production (herbaceous crops, forage, vegetable, grain, fruit, oil, root, and tuber crops). In general, AquaCrop has been used to simulate crop development, yield production and water-related variables such as evapotranspiration, Water Use Efficiency, and water productivity, while considering different stressed conditions (Greaves & Wang 2016), such as: the leaf growth and canopy expansion, the stomatal conductance and canopy senescence, the pollination failure and the harvest index (Greaves & Wang 2016). Different studies around the world have been conducted using AquaCrop (Zouidou et al. 2017; Dalla et al. 2019).

Hydrus 1D provides numerical solutions for the Richard's equation, requiring imputs such as: meteorological data, soil parameters and others (Šimunek et al. 2013). As Hydrus can require different types of parameters, for a better simulation of it, some calibration for some of the parameters could be needed (Bordoni et al 2018). Hydrus 1D was used in some different studies regarding soil moisture, focusing on different situations (Da Silva et al. 2015; Wang et al. 2018).

The aim of this work was to compare the soil moisture value obtained with these two models with data obtained on site at a research field in Gödöllő and see how they perform under the same conditions.

MATERIALS AND METHODS

The modeling was done for the years of 2020 and 2021 considering the area of the MATE agricultural research station in Gödöllő. The same soil and climate parameters were used for both Hydrus and AquaCrop models and the upper soil layer was considered. The soil parameters were based on the 2018 CORINE (CORINE 2018) Land Cover dataset and the climate ones were taken from two different sources, for 2020 it was from (OMS 2022) and for 2021 it was taken from the climate station that is located at the research field.

The simulation period for the models was the entirety of both 2020 and 2021 and for both years wheat was considered for the growing period of plant cover.

RESULTS

For 2020 (Fig. 1) it can be seen that both AquaCrop and the Hydrus modeled results react in a similar way to the precipitation intensity, having similar patterns trought the year. Both have similar values in the middle of the year, when the crop growth is happening and in the beggining and end both of their values have a considerable change in intensity, but still reacting with the same pattern.

Figure 2 shows the modelled soil moisture with Hydrus and the soil moisture results obtained at the research field on site. It is possible to see that the results do no match, just having a bit of the same reactions for the precipitation. AquaCrop wasn't considered in this comparassion, as the results that were gotten from it were not satisfactory.

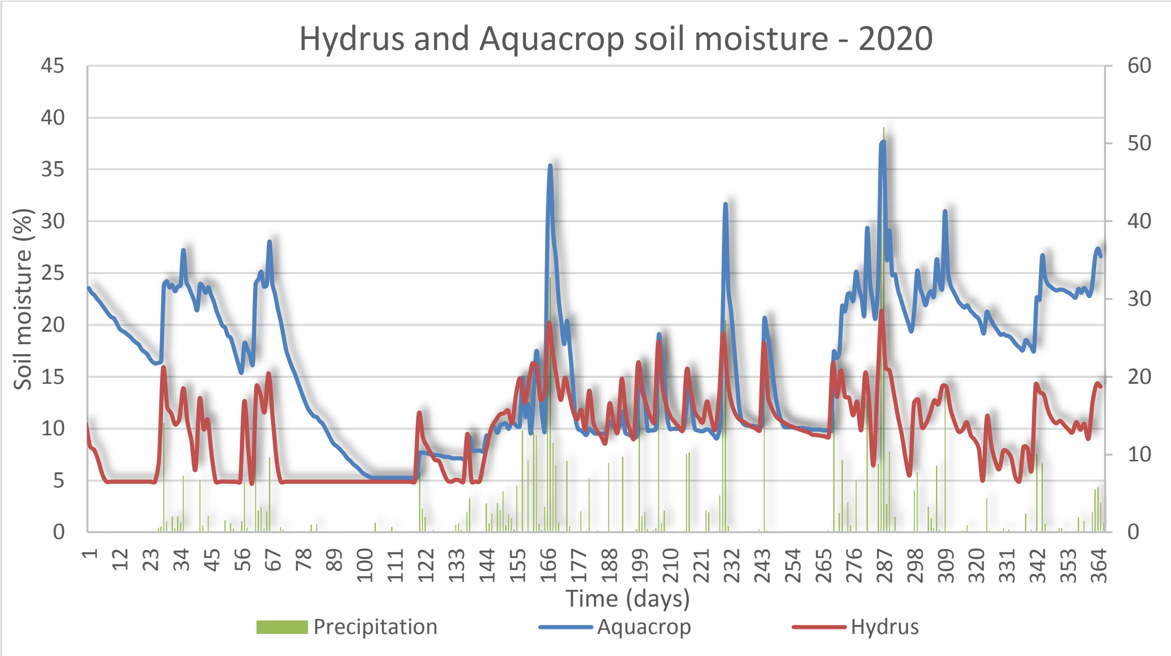

Figure 1. Hydrus and AquaCrop Soil moisture - 2020

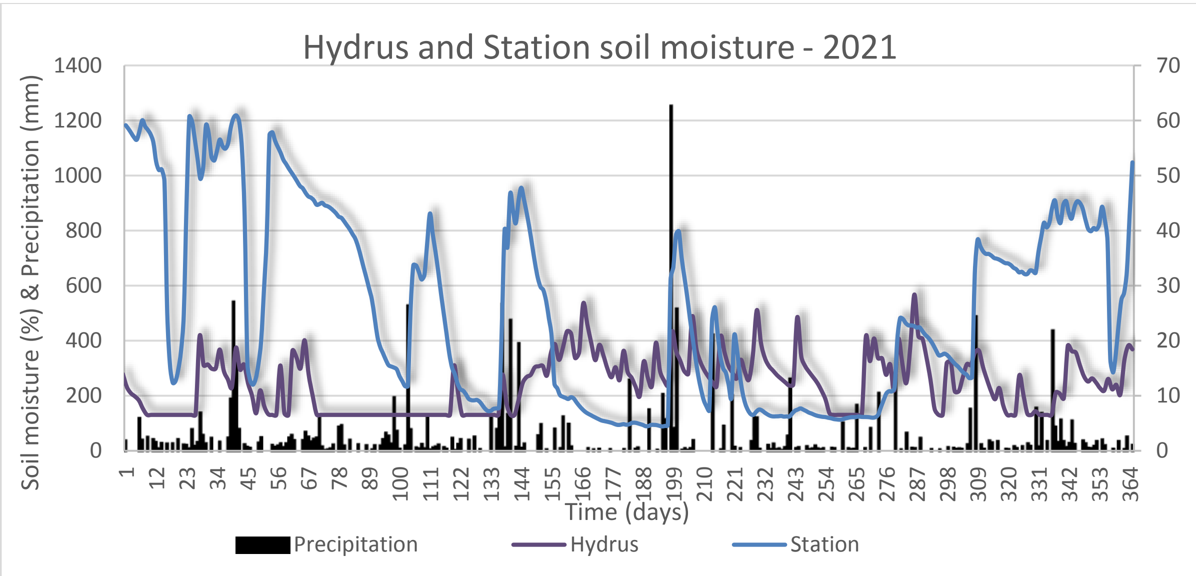

Figure 2. Hydrus and Research station Soil moisture - 2021

DISCUSSION AND CONCLUSION

The results in figure 1 show a good comparassion in one aspect between the two models, even though overal they have a considerable difference between then. What can be seen is that for the duration of crop growth both of the models act in a similar way. An important difference that can be seen in this period is that aquacrop reacts in a stronger wat to the precipitation, having higher peak values, that is probably due to how both models deal with the water tranport trough the soil.

For the results of 2021 (fig. 2) not much can be taken from it, as the results from AquaCrop are not able to be used and the station values are really different from the modelled ones. Some things that can be seen from the station soil moisture values are that, the values are quite high around winter, close to 60%, which is higher than what it should be, showing that there might some errors with the water moisture sensor. Another charachteristic is that there is a small lag between the rainfall and the response from the soil moisture seen at the field.

Even though the results for the year of 2021 were not the best to be used, some things can be used from what was seen, specially for year of 2020. A change in some of the parametrization of the models should be needed for better results, but with an adequate result for the growing period, it can be said that both models present adequate values for that period, but a validation would be needed to better know if the parameters used can achieve a better result when compared to field studies in the area.

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DETECTION OF SOME PHYSICAL SOIL PROPERTIES BASED ON THE MID-INFRARED SPECTRAL LIBRARY: SALT AFFECTED SOILS TYPE, HUNGARY

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ABSTRACT

Out of all the physical soil properties, quantifying among others the soil texture, as well as bulk density, are required for the assessment of the diverse environmental functions including water balance of soils and pore structure, water erosion and various soil hydraulic properties. The mid-infrared spectroscopy is a useful technique to predict soil attributes with high accuracy, efficiency and low cost. In this study, we examined the ability of our mid-infrared soil spectral library for predicting the clay, silt, sand content and bulk density. This research is part of a project to establish a mid-infrared spectral library in the frame of the Hungarian (SIMS) survey. Salt affected soils type data was extracted from the spectral library then transformation of spectral reflectance values to absorbance values were performed. Moving average filtering method was applied to absorbance spectra before performing principal components analysis. To determine outlier samples and to select the proper samples for model calibration Mahalanobis distance-based outlier detection method and Kennard-Stone Sampling selection method were applied on the principal component scores. Spectral and reference soil data were combined and split into training and testing datasets. MIR prediction models were built for sand, clay, silt content and bulk density using partial least square regression method. Coefficient determination, root mean square error and ratio performance to deviation were used to assess the models performance. The prediction accuracies of calibration for soil physical texture were excellent ($R^2 \geq 0.92$, RPD $\geq$ 3.54 and RMSE $\leq$ 4.3) while the validation results were slightly lower ($R^2 \geq 0.80$ and RPD $\geq$ 2.23) but still with a good level of prediction. Bulk density was produced a much poor model with no predictive abilities in both calibration and validation datasets.

INTRODUCTION

Soil physical attributes are required for different disciplines' study. It’s critical for agricultural production and long-term soil use. One of the most essential soil physical features for determining infiltration rate, irrigation, and drainage practices is physical soil texture. It has a big impact on soil hydraulic characteristics not least water permeability, soil water retention (Wösten et al., 2001) and solute dispersion in the soil profile, therefore it's important for general agriculture, the environment, and land reclamation (Li et al., 2014). E.g. the higher the porosity and water retention of the soil, yet the slower the permeability, the finer the texture. On other hand, convection attributable to upward water movement in reaction to evapotranspiration, diffusion due to a salinity gradient with depth, and limited drainage flow are the major causes of salt transfer to the soil surface (Kessler et al., 2010). Both soil water dynamics and salt accumulation phenomena affected by physical soil texture. Thus, knowing and analyzing the texture of the soil is vital to understanding how well it functions related to plants and other soil processes. In addition, bulk density (BD) is a key measure of soil quality, productivity, compaction, and porosity. The major application of BD is to estimate soil compaction that affect many soil water properties.

Various approaches could be used to identify the physical texture of soil. The most two important traditional assessment methods for soil texture are, hydrometer and the sieve-pipette, both are granulometric measurements of particle size using gravitational-sedimentation techniques. These methods have many disadvantages, they are extremely time-consuming and inaccurate e.g. under-estimate or overestimation of clay (Thomas et al., 2021). In addition, H_2O_2, HCl, $C_6H_5Na_3O_7$ and $NaHCO_3$ chemical compounds are necessary as pretreatment to remove soil organic matter, Fe oxides and carbonates. These compounds may generate toxic wastes that are environmentally harmful. Last but not least its application across large fields (e.g. soil survey activities and soil mapping) is impractical and expensive. In contrast to the approaches listed above, infrared spectroscopy has emerged as a feasible option for time- and cost effective solution for soil property determination. It's a low-cost, non-destructive method that doesn't need any chemical extraction (Ng et al., 2022). A single spectrum can be used to predict many attributes at the same time. Fundamental molecular vibrations absorb electromagnetic radiation at specified wavelengths, resulting characteristic spectral fingerprints in mid-infrared region (2.5-25 mm) which is sensitive to soils' organic and mineral components. Various physical and chemical soil properties, including texture, have been detected using MIR spectroscopy.

On the other hand, the soil science community has been working hard recently to create extensive soil mid-infrared spectral libraries on a national and global scale. Soil spectral libraries often contain significant amounts of soil samples that represent the diversity of soils in a given region. MIR spectral library has been shown to accurately estimate soil texture in addition to many soil attributes such as soil organic carbon, CEC, phosphorus and potassium content. The generation of prediction models based on the appropriate calibration dataset and robust algorithms is required for the accurate estimation of soil properties. In this regard, the Partial Least-squares Regression (PLSR) is a powerful technique compared to other algorithms (easy to compute and interpret).

The goals of this study were to: build multivariate statistical models for some physical properties using PLSR and test predictive the capacity of MIR spectral library for sand, clay, silt content and bulk density.

MATERIALS AND METHODS

Study area and dataset

This research utilized spectral data from the MIR spectral library which is being built based on the samples collected in frame of Hungarian Soil Information and Monitoring (SIMS) survey. Salt affected soils type dataset was extracted from the spectral library which contains about 100 soil samples.

Dataset preprocessing, calibration sample selection and soil physical properties prediction models:

Applying preprocessing methods for spectral dataset were used to enhance the accuracy of quantitative soil analysis**.** The MIR spectra were transformed from reflectance to absorbance value. Absorbance spectra dataset were smoothed with a moving average window of 17 bands and Savitzky-Golay filtering methods to reduce and remove noise that represents random fluctuations in the signal. Principal Component Analysis (PCA) was applied to reduce the dimensionality of the spectral dataset, improve computational efficiency and to compress the spectral information into a few variables (principal component scores).

For detecting outliers, namely to identify samples that deviate from the average sample population Mahalanobis distance and H distance between the samples were calculated on the principal component scores derived from the spectral dataset.

To define how many observations (samples) should be listed as calibration dataset Kennard-Stone Sampling selection method was applied on PC scores. SAS spectral dataset including reference soil data was split into training and testing datasets. Accordingly, 27 soil samples were selected for calibration dataset and remaining samples were retained for the validation set (n = 64).

MIR prediction models were built for sand, clay, siltv content and bulk density using partial least square regression method based on calibration dataset. The models were validated using the independent validation sample set. Coefficient of determination (R^2), root mean square error (RMSE) and ratio performance to deviation (RPD) were used to assess the model's performance.

RStudio software (R Core Team, 2020) was used for spectral displaying, analysis and modelling processes using several packages, functions and operators.

RESULTS AND DISCUSSIONS

Figure 1 represents the MIR spectra involved into this study. The general shape, the position of the absorption features are determined by the physical-chemical composition of the samples. Since soil clay, silt and sand content refers to particle size classes involving a wide range of mineral particles the direct visual attribution of spectral features to these soil properties is limited. However the careful visual interpretation of the spectral data reveals that the spectral features of clay minerals are clearly and the ones of quartz are less identifiable. For example, due to OH stretching, clays or aluminosilicates display strong peaks around 3700 1/cm. Furthermore, the band about 1630 1/cm is usually assumed to be caused by water in the clay. The complex band at roughly 1048 1/cm may due to clay mineral spectra, which is connected to the stretching vibrations of Si-O groups (Tinti et al., 2015). A sharp band at 798 1/cm with a shoulder around 779 1/cm prove the existence of quartz mixes (Madejová, 2003). In addition, the clear band ranging between 2562 - 2480 1/cm may assigned to the vibration of molecules in quartz minerals.

Figure 2 represents the model results of the spectral-based soil texture and bulk density determination for training and validation sets. Overall, components of physical soil texture were predicted excellent using the calibration sets. The prediction accuracy for total sand, total clay and total silt of the calibration dataset were very high with the coefficient determination of 0.96, 0.92 and 0.94 and ratio performance to deviation of 5.33, 3.56 and 4.13 respectively. Whereas the root mean square error is 3.85 for silt and 0.43 for sand and clay. The validation sets prediction accuracy is well but was slightly lower than the calibration set (figure 2). Total sand content had (R2 = 0.88, RMSE = 8.42, RPD = 2.92), total clay had (R2 = 0.8, RMSE = 7.11, RPD = 2.23), while total silt (R2 = 0.8, RMSE = 6.38, RPD = 2.27). The model parameters for the validation set represent the real performance of the models.

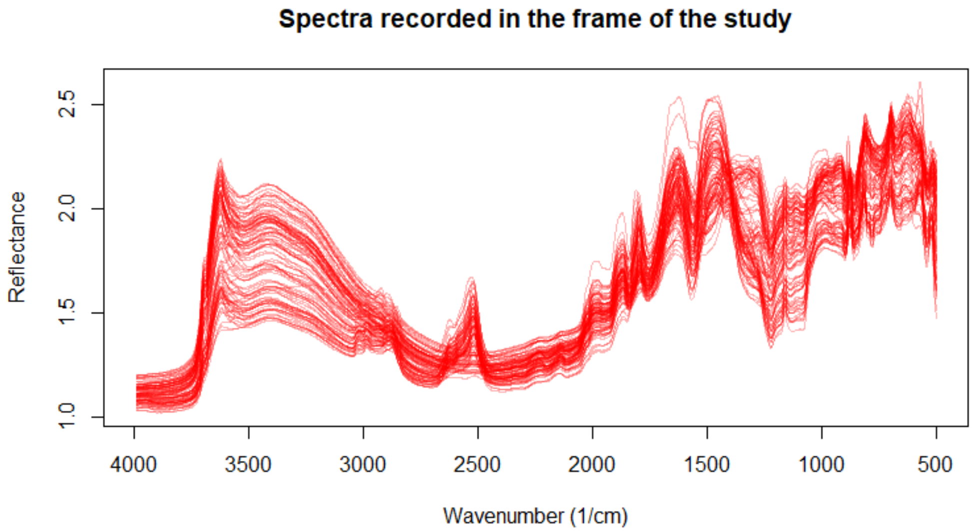


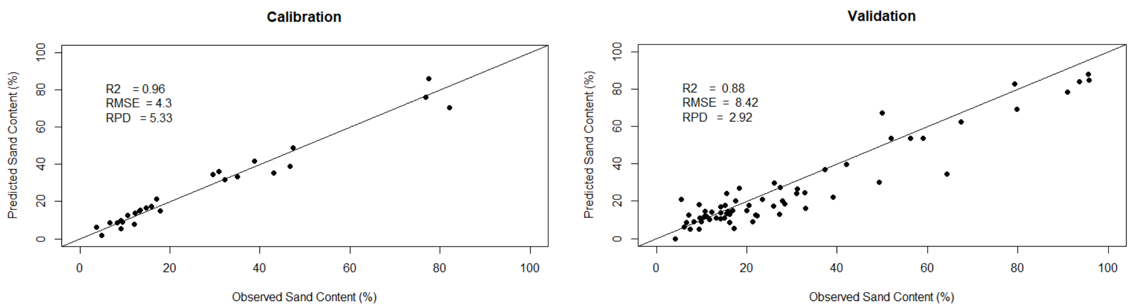
Figure 1. Mid-infrared spectra of salt affected soil dataset

Generally, the good performance models for sand, clay and silt content may be attributed to the high spectral activity of these materials in the MIR region. Specifically, because certain molecules in minerals are spectrally active compounds, clay percentage can be accurately predicted. While sand content can be accurately estimated for the reason of the high negative association between total sand and total clay content and the clear presence of the absorption features of quartz.

Models' performance assessment for bulk density showed very poorly predicted values in the calibration and validation data sets with no predictive abilities (figure 2). That can be attributed to the fact that bulk density does not have direct spectral response since it is a soil property determined and influenced by a wide range of factors that do not have spectral fingerprints.

CONCLUSION

This study has demonstrated that MIR spectral libraries contain useful information related to soil texture and could be used for cheap, fast and reliable prediction of soil texture in salt-affected soil types.



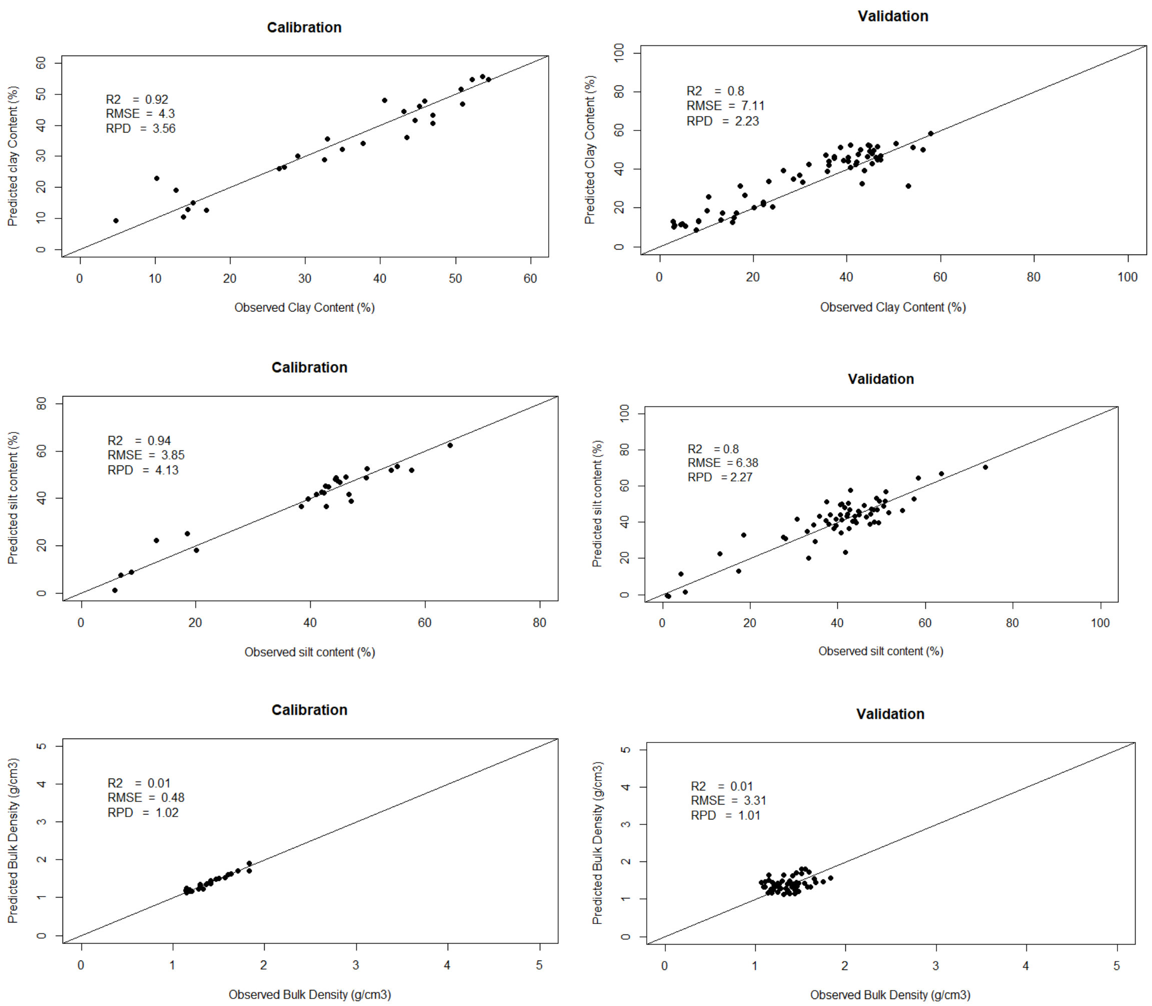


Figure 2. Scatterplots of predicted versus observed values at calibration and validation sets of clay sand, silt and bulk density obtained from PLSR models.

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SOIL AND WATER CONSERVATION IN KENYA; PRACTICES, CHALLENGES AND PROSPECTS

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ABSTRACT

Adoption of Soil and water conservation (SWC) technologies is seen as a long-term solution to soil erosion, a way of improving the soil water conditions and enhancing soil carbon sequestration potential. This paper reviews the numerous SWC practices in Kenya, challenges facing their implementation and adoption, and future opportunities. A review of existing literature from journal articles, conference papers, policy documents, and government reports formed the paper's basis. The common SWC practices in Kenya include terracing, contour farming, mulching, cover crops, manure, agroforestry, improved fallows, conservation tillage, intercropping, cut-off drains, retention, and infiltration ditches. The adoption of these technologies is primarily influenced by several socio-economic and institutional factors and farm characteristics. Challenges facing SWC technologies' adoption include inadequate stakeholders' coordination, financial constraints, land tenure insecurity, poor policy enforcement, political interference, and cultural issues. Improved adoption and proper implementation of SWC technologies in Kenya has the potential of increasing crop production through better soil conservation, reduced erosion, and improved available soil moisture for plant use. It will also significantly boost the food security of the nation as envisioned in the national government's big four agenda and help combat climate change.

Keywords: Soil erosion, green water, surface runoff, soil quality

INTRODUCTION

SWC is defined as any practice that reduces water runoff and soil erosion thereby allowing the soil to be conserved (Gachene et al., 2020). Soil is the most basic and essential resource for food, feed, fuel, and fiber production. As a result, it supports food security and environmental quality, both of which are critical to human survival (Blanco-Canqui & Lal, 2010). All terrestrial life requires soil and water in order to exist and survive (Kumawat et al., 2020). Land degradation is a problem in many parts of the world. Among the different degradation processes, soil erosion poses a severe threat since it results in the deterioration of soil and water resources. Soil erosion is one of the major issues confronting Sub-Saharan African countries as they try to boost agricultural output and reduce poverty and food insecurity (El-Swaify, 1997; Gebremedhin, & Swinton, 2001). To prevent future land degradation, a number of soil and water conservation measures have been promoted in recent development initiatives in developing countries, with mixed outcomes (De Graaff et al., 2008). SWC approaches include structural, vegetative, and agronomic strategies that can reduce surface runoff and soil erosion while also improving infiltration and soil fertility (Liniger & Critchley, 2007).

Farmers worldwide have embraced soil and water conservation methods to ensure the long-term productivity of their soils by reducing soil erosion and conserving soil moisture. SWC also aids in the reduction of on-farm costs, the improvement of soil fertility, and the reduction of hazardous contamination of surface and groundwater (Ajayi, 2007).

Kenya is an East African nation that covers an area of 581,309 km^2 with an estimated total human population of about 47,564,296 people as of the year 2019. It is geographically divided into 47 administrative units of the devolved government called counties (Government of Kenya, 2010; Kenya National Bureau of Statistics, 2019). Kenya's climate is divided into seven distinct Agro-climatic zones (ACZs), each with its rainfall and temperature patterns (Sombroek et al., 1982). Kenya's average annual rainfall is 630 millimeters (mm), ranging from less than 200 mm in Northern Kenya to more than 1,800 mm on Mount Kenya's slopes (Marshall, 2011). The varying amount and distribution of rainfall in most regions of Kenya, both throughout and between seasons, makes the availability of water for crop production uncertain and farming a risky endeavor (Rao and Okwach 2005). According to the FAO-UNESCO categorization, Kenya has 22 major soil groups. Solonetz dominates Kenya's northeastern and northwest arid areas, whereas Nitisols predominate in the humid areas and Cambisols predominate in the highlands (Omuto, 2013). The agriculture sector is the pillar of the Kenyan economy, contributing about 27.3% of the GDP directly and another 25% indirectly through linkages with other sectors. Agriculture contributes 75% of industrial raw materials and 60% of export earnings. The sector also accounts for 65% of Kenya's total exports, 18%percent of formal employment, and 60% of the total employment (Republic of Kenya, 2020). Only around 20% of Kenya's land is classed as having medium to high potential, which supports large population densities, while the remaining 80% is mostly arid or semi-arid, and only a small proportion of the population lives there (World Bank, 2008). Kenya suffers from high soil erosion, which is estimated to be 72 tons per hectare per year (de Graff, 1993). Soil erosion and water scarcity are, therefore, among the major environmental problems and threats to rural development in Kenya (Nyangena, 2008; Marshall, 2011).

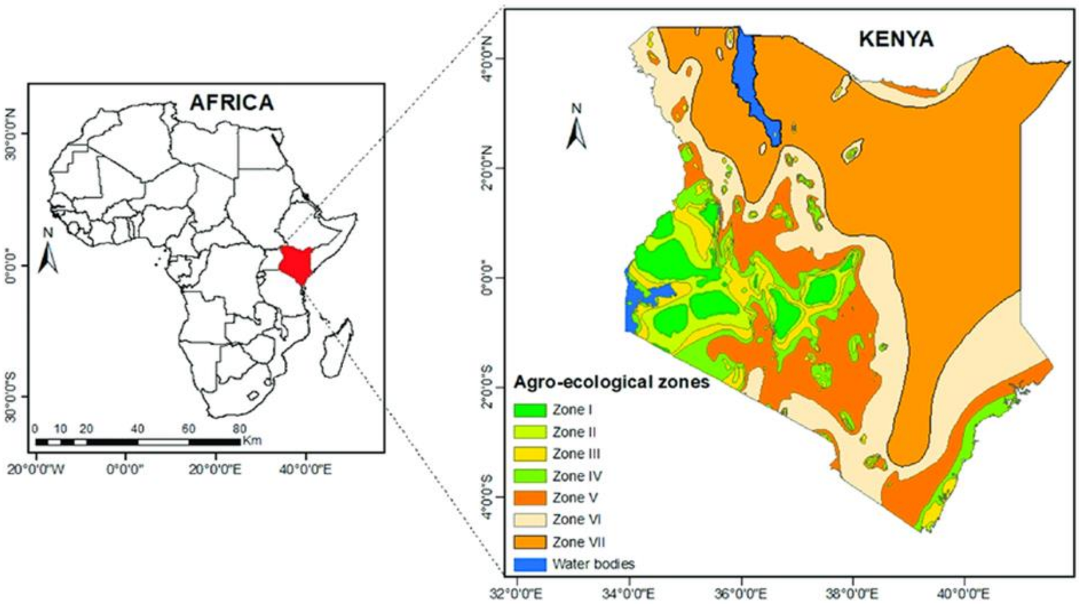

Fig. 1: Map of Kenya showing the various agroecological zones (Kogo et al., 2019)

SWC practices in Kenya

Due to significant soil erosion problems on both settlers and African farms, colonial authorities introduced SWC in Kenya in the 1930s. Local authorities and agricultural personnel strictly enforced these rules, and non-compliant farmers were subjected to harsh penalties. Contour farming, tree planting, terrace strip cropping, and destocking were the primary SWC practices enforced (Gachene et al., 2020). With time, however, the government and donors changed their approach to encourage SWC technologies by offering various incentives to farmers to support soil conservation after the country gained independence and farmers' disdain of coerced SWC.

Terraces, infiltration ditches, and bunds were frequently advocated as cross-slope SWC technologies (Nyangena, 2008).

The National Agricultural and Livestock Extension Program (NALEP), which is under the Ministry of Agriculture, is currently managing and coordinating soil and water conservation efforts in the country (Owino, 2003). Numerous SWC technologies are practiced in different parts of Kenya with mixed outcomes. SWC practices in Kenya can be grouped into four broad categories (Table 1): agronomic practices, vegetative practices, structural measures, and overall management. Detailed description of the individual SWC practices under each category is extensively covered by Karuku. (2018) and Gachene et al. (2020). The agronomic and vegetative practices aim to increase soil surface cover and surface roughness while increasing surface depression storage and infiltration (Karuku, 2018). Conservation tillage and contour farming are examples of agronomic practices, while strip cropping, intercropping, and agroforestry form the vegetative practices (Karuku, 2018). Agronomic and vegetative SWC approaches are popular predominantly in sub-Saharan Africa due to their low cost of adoption compared to the structural SWC measures (Gachene et al., 2020). Structural measures of SWC are mainly implemented in croplands to change the slope profile of the land to control surface runoff and soil erosion. It entails terraces, ridging, and contouring. Their construction typically involves earthmoving, which requires substantial initial inputs of capital or labor (Gachene et al., 2020). Overall management involves area closures and selective clearing (Karuku, 2018).

The above categories of SWC practices have been applied individually and in combination by farmers in the various regions of Kenya. The *'fanya-juu'* terracing system is common in the semi-arid region of Wote, Makueni county South Eastern Kenya (Saiz et al., 2016). It entails digging out ditches along contour lines and depositing soil uphill to make a mound to create embankments along a slope. In the Ngaciuma sub-catchment former Eastern province of Kenya, the major SWC technologies include terracing, mixed cropping, agroforestry, cover cropping, and contour vegetation strips (Alufah et al., 2012). The most practiced technologies of SWC in both highland and lowlands of Kapenguria area, upper Turkwel watershed in West Pokot County, are terracing, check dams, stone bunds, cover pasture and strip cropping (Toromo et al., 2019) while tied ridges and mulching were practiced in Katumani and Makindu in Machakos and Makueni counties Eastern Kenya (Leal Filho, 2005).

Table 1: Summary of the various SWC practices in Kenya (Karuku, 2018; Gachene et al., 2020)

Agronomic practices	**Vegetative practices**	**Structural measures**	**Overall management**
• *Cover crops* • *Mulching* • *Crop rotation,* • *Intercropping* • *Farmyard manure* • *Inorganic fertilizer* • *Minimum tillage* • *Contour farming*	• *Agroforestry* • *Strip cropping* • *Intercropping* • *Live fences* • *Windbreaks*	• *Terracing e.g., Fanya juu* • *Ditches* • *Water retention pits* • *Stone/contour bunds* • *Check dams* • *Contouring* • *Cut-off drains* • *Trash/log lines*	• *Rational grazing* • *Selective clearing* • *Area closure* • *Destocking*

SWC measures in the Saba Saba sub-catchment of the upper Tana catchment comprise bench terraces, *fanya Juu*, contour bunds, mulching, napier grass strips, and cut-off drains. Bench terraces are found primarily in the upper and middle zones of the sub-catchment, contour bunds mainly in the center, and Napier grass strips in the lower zones (Atampugre, 2014). In Kenya's Upper-Tana basin, mulching, vegetative contour strips, and tied ridges are employed for SWC, while in Meru County's Semiarid Mbeere, a combination of *fanya Juu*, stone bunds, loglines, and trash lines, are used for SWC (Ellis Jones & Tengberg, 2000; Hunink et al., 2012).

Zai technology is common in Tharaka South sub-county, Tharaka-Nithi County, located in Eastern Kenya (Kimaru-Muchai et al., 2020; Ndeke et al., 2021). It entails the creation of small planting areas and water collection basins filled with manure, compost, or dry biomass for the restoration and rehabilitation of severely degraded, encrusted soil, as well as in landscapes where runoff is a problem (Roose et al., 1999). It was introduced and continually promoted by development organizations in the drylands of upper Eastern Kenya in an attempt to alleviate the region's intra-seasonal dry spells (Kimaru-Muchai et al., 2020).

Indigenous soil and water conservation (ISWC) practices were also noted in the Mbeere district, a semi-arid part of eastern Kenya. The most common techniques used are trash lines, stone bunds, *fanya Juu* and log lines (Tengberg et al., 1998).

Factors influencing the adoption of SWC practices in Kenya

Adoption of SWC methods is influenced by a number of socio-economic, farm, and institutional factors, many of which are unique to a certain geographic location. Many of these variables, such as natural resource endowments and agroclimatic conditions, affect the costs, returns, and risks of SWC investments and practices (Pender & Kerr, 1998; Njenga et al., 2021b).

A comparative study by Nyangena (2008) in three districts of Machakos, Kiambu, and Meru revealed that the investment in SWC was influenced by social capital in the form of tenure security and economic variables. Enabling government policies and good infrastructure, which lowered transportation costs and eased market access, were other important factors in the adoption of SWC (Nyangena, 2008). Kabubo-Mariara et al. (2009) report that farm characteristics, development domain dimensions, and presence of village institutions in determining adoption and also the intensity of SWC investments. They further highlight the importance of tenure security and household assets in determining the adoption and intensity of soil and water conservation investments.

Research carried out in the Eastern, Central, Western, and Rift valley regions of Kenya showed that land ownership and access to off-farm income had a positive association with the adoption of SWC. Conversely, the skills and technical know-how essential for implementing and maintaining a technology on the farm had a negative influence on the adoption of SWC technologies among smallholder farmers (Karanja Ng'ang'a et al., 2020). In the Yatta and Mwala sub-counties of Machakos county, gender, age, education level, access to agricultural credit, and extension services were found to influence the adoption of SWC technologies. Additionally, access to information, farm inputs, availability of labor, appropriate equipment farm implements, access to the market, and farmers' perception of rainfall reliability were also significant in adopting SWC technologies (Akuja et al., 2016).

Socio-economic, farm characteristics, and institutional factors were found to have an influence on the adoption of knowledge-intensive technologies in the dry zones of the central highlands of Kenya. These factors comprised gender, education level, farm size, number of livestock kept, farmers' perceptions of soil fertility, farmer group membership, access to training, access to agricultural credit, and farm equipment (Njenga et al., 2021b).

The decision by farmers in the Ngaciuma sub-catchment, former Eastern province of Kenya, to adopt SWC was influenced by farm characteristics, institutional, socio-economic, technological attributes, and other exogenous factors (Alufah et al., 2012). It was noted that land ownership, household size, training in soil erosion control, perception of soil erosion problems, and access to institutional credit had significant effects on the adoption of SWC technologies. The study further revealed that age, the slope of cultivated land, the distance of the farm from the river, and membership to a group had a positive influence on the adoption of SWC. In contrast, the level of education, number of farm parcels, and distance of the farm from homestead had a negative effect on the adoption of SWC technologies (Alufah et al., 2012).

A study conducted in the Kathekakai settlement scheme, Machakos district revealed gender as a critical factor in adopting SWC technologies. Women's efforts to adopt the recommended technologies were hampered by their limited access to authoritative information and lack of control over land-use decisions (Gathaara et al., 2009). In Upper Eastern Kenya's drylands, gender-specific determinants of Zai technology choice and use intensity were also reported (Ndeke et al., 2021). Household size, age of the household head, farm size, access to credit, number of accessible markets, and tropical livestock units were generally associated with reduced adoption lag of SWC practices among smallholder farmers in the Sio-Malaba Malakisi River Basin border region of Kenya and Uganda (Nyirahabimana, 2021). Despite being advocated for, the adoption rate of SWC technologies in the dry zones of Tharaka-Nithi County by smallholder farmers has remained stagnant over time. This has been linked to the fact that there are significant communication gaps between farmers, agricultural extension officers, and researchers (Njenga et al., 2021a)

Kimaru-Muchai et al. (2020) found out that farm characteristics and socio-economic characteristics played an essential role in adopting Zai pits in the drier upper Eastern zones of Kenya. These comprised the farmers' wealth status, the number of non-formal training, and the membership to social groups. The adoption of SWC in the Njoro River Watershed of Kenya was influenced by education, household income, land tenure security, and perception of soil fertility (Huckett, 2010). Table 2 below shows a summarized analysis of the specific socio-economic, institutional, and farm characteristics and their significance in adopting SWC in Kenya.

Based on our analysis (Table 2) it is evident that gender, household income and education are the key socio-economic determinants of SWC adoption. Market access and access to credit are the outstanding institutional factors of SWC adoption while land tenure is a crucial farm characteristic that influences the adoption of SWC by farmers in Kenya.

Challenges facing SWC in Kenya

Despite the efforts by government authorities and Non-Governmental Organizations (NGOs) to promote SWC, several challenges stand in the way of adopting and implementing these technologies in Kenya. Financial constraints and administrative issues on the governments' side have curtailed the smooth implementation of SWC programs. This has been characterized by a lack of sufficient staff in the form of extension officers, lack of infrastructure, and limited budgetary allocation to the agricultural sector at the national and county government levels for efficient implementation of SWC technologies, among other agricultural programs (Republic of Kenya, 2020). Staff changes in transfers and natural attrition also lead to disruption and delayed implementation of SWC programs (Mutisya et al., 2010). Lack of funds, insufficient technical know-how, and shortage of labor are the other notable challenges smallholder farmers face in implementing SWC in Kenya, especially for structural measures (Toromo et al., 2019; Gachene et al., 2020).

Land tenure insecurity is another challenge in adopting SWC technologies in Kenya. Land users may not be willing to invest in long-term SWC technologies such as terracing if they are unsure of reaping the benefits from such work in the long run (Republic of Kenya, 2020). Lack of individual user responsibility for soil and water conservation is also common in regions where land is owned communally. Culture is also a barrier to SWC. Some communities do not allow women to own land and participate in SWC activities freely despite women being the important implementers of environmental and agricultural activities in Kenya (Mutisya et al., 2010).

Poor land and agrarian policy formulation and lack of enforcement where they exist have been cited as another SWC challenge. Political interference has also been noted in the past where politicians excise sections of forests to their supporters as a bribe for their votes or repayment for political patronage reversing the SWC gains and posing a threat of land degradation (Karuku, 2018). The Republic of Kenya (2020) further notes a gap in the dissemination and uptake of SWC technologies due to poor linkage between research and extension. Lack of farm planning and inadequate coordination between various stakeholders disseminating soil and water conservation interventions has also slowed down the implementation of SWC programs (Republic of Kenya, 2020).

Table 2. Farm characteristics, Socio-economic and institutional factors and their influence on the adoption of SWC technologies

Factors influencing SWC adoption	Frequency of mention	References
Socio-economic factors		Kimaru-Muchai et al., 2020; Nyirahabimana, 2021; Ndeke et al., 2021; Gathaara et al., 2009; Alufah et al., 2012; Njenga et al., 2021b; Karanja Ng'ang'a et al., 2020; Huckett, 2010; Toromo et al., 2019
• Age	+++	
• Gender	++++	
• Education	++++	
• Household size	++	
• Household income	++++	
• Skills and technical know-how	++	
Farm characteristics		Nyirahabimana, 2021; Alufah et al., 2012; Njenga et al., 2021b; Kabubo-Mariara et al., 2009; Karanja Ng'ang'a et al., 2020; Nyangena, 2008; Huckett, 2010
• Land tenure	++++++	
• Farm size	++	
• Perception of soil fertility	++	
• Perception of soil erosion problem	+	
• Distance of farm from homestead	+	
• Number of farm parcels	+	
• Tropical livestock unit	++	
• Distance of farm from the river	+	
• Slope of cultivated land	+	
Institutional factors		Kimaru-Muchai et al. 2020; Njenga et al., 2021a; Nyirahabimana, 2021; Alufah et al., 2012; Njenga et al., 2021b; Karanja Ng'ang'a et al.,
• Market access	++++	
• Access to agricultural extension services	+	
• Access to credit	+++++	
• Non-formal training	+++	
• Membership in social groups	+++	

• Access to information	++	2020; Nyangena, 2008;
• Access to labor	++	Toromo et al., 2019
• Access to farm equipment	++	
• Government policies	+	
• Access to farm inputs	+	

Opportunities

Integrated soil fertility and soil water conservation technologies are possible solutions to the low per capita food production in Sub-Saharan Africa (Njenga et al., 2021b). Research findings have shown improved yields in farms practicing SWC in most regions of Kenya (Ngugi et al., 2015). Therefore, the use of soil and water conservation technologies is indispensable in ensuring food security in semi-arid regions where rainfall is very variable and a tool for dealing with the challenge of land degradation in the country. SWC measures have great potential for increasing soil organic matter (SOM) levels by reducing erosion, which is the key agent of lateral soil exports, thereby enhancing the carbon sequestration ability of a particular soil. SWC strategies have been proven to increase SOM storage potential in agricultural lands in Kenya (Batjes, 2014; Saiz et al., 2016). Therefore, proper and effective implementation of SWC measures will go a long way in mitigating climate change and its associated impacts both locally and globally.

Some farmers in Kenya still use traditional practices in SWC (Ellis Jones & Tengberg, 2000). Combining these cultural practices with researcher-based knowledge and findings will result in better outcomes for apt integrated soil and water management practices. After the promulgation of Kenya's new constitution 2010, the devolution of agricultural soil management practices further presents an excellent opportunity for effective implementation of SWC through the agricultural extension system at the grass-root level. The formulation of the National Agricultural Soil Management Policy (NASMP) of 2020 is a step in the right direction for improved SWC. It will ensure regulated and coordinated investment in agricultural soil management in Kenya if properly implemented (Republic of Kenya, 2020).

CONCLUSION AND RECOMMENDATIONS

The agricultural sector is vital in the economy of Kenya as a nation as it is a source of livelihood to most of its citizens and also a key contributor to the GDP. The sector hasn't realized its full production potential due to many challenges, including soil erosion and insufficient amount of water for crop production. SWC practices present an opportunity for curbing these challenges and improving the food security situation in Kenya while also mitigating the impacts of climate change. However, the adoption of these technologies is wanting due to constraints associated with socio-economic factors, institutional factors, and farm characteristics.

Therefore, for better outcomes of SWC practices in Kenya, we recommend the following.

- Resource mobilization and improved budgetary allocation by the central and county governments to the agricultural sector to support SWC extension programs and practices.
- Improved land tenure security by issuing title deeds to private landowners without titles to encourage individual farmers' investment in long term soil and water conservation measures.

- Combining indigenous soil and water conservation practices with contemporary researcher-based knowledge and findings for an integrated soil and water conservation
- Provision of incentives to farmers who practice SWC to inspire the adoption of SWC by more farmers.
- The government should also facilitate farmers' access to agricultural credits and markets and ensure the affordability of appropriate technologies and equipment required for soil and water conservation.
- Effective enforcement of existing land use and agricultural regulations to reduce further degradation of agricultural landscapes and promote soil and water conservation.
- Promotion and advocacy of more women inclusion in the implementation of SWC projects by the local government and NGOs at the household level for improved outcomes.

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STATISTICAL ANALYSIS OF RECENT WATER SUPPLY DEVELOPMENTS IN ROMANIA

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ABSTRACT

The distribution of water in Romania in recent years shows certain changes most frequently at the level of domestic consumers and in agriculture. The study is based on statistical data presented by the National Institute of Statistics of Romania, concerning the quantity of water distributed to the population, in industry and construction and in agriculture. The period analysed is five years, 2016-2020. Changes in the evolution are observed in the year 2020, which has a particular character due to sanitary restrictions imposed in that period.

Keywords: water distribution, statistics

INTRODUCTION

The increase in the number of rural areas of Romania connected to the water distribution network has completed the number of people benefiting from this service, reaching more than 72% of the resident population in 2020 (Mocanu 2011;NIS 2022). Agricultural production in Romania has an increasing trend following the average values per unit area of the main agricultural crops. All this leads to an increase in water needs. At the same time, there are improvements in the distribution system, with multiple investments made for this purpose helping to reduce losses. The educational factor also implies a different behaviour of the population regarding water use in the sense of saving water consumption (Huma 2015). Water saving continues to be a topical issue, involving a balanced relationship with the supply of water for a decent life (MDG 2022) and the coverage of needs in industry and agriculture (Blanke 2007; Cao 2020) as well as environmental protection (Aquatim 2020). The aim of the paper is to verify whether the annual changes in the quantities of water distributed are statistically significant, emphasising the particular nature of the year 2020 in a pandemic context.

MATERIAL AND METHOD

The National Institute of Statistics of Romania (NIS) reports statistical data on water distribution grouped by river basin, by consumer category and by year. In order to make comparisons, the amounts of water distributed in the Romanian river basins were tested in terms of differences measured from one year to another. The ANOVA with repeated measures test was used, together with Tukey's pairwise and Friedman's non-parametric test using Past 4.03 (Hammer 2001). Descriptive statistics (Brudiu 2012) were performed using SAS Studio (SAS 2022).

RESULTS AND DISCUSSIONS

The NIS statistics led to the summary statistics in Table 1. Within the variables the consumer categories are listed, where P is the population, IC is industry and construction, AF is agriculture and fish farming, and T is the total quantity, which includes in addition to the sum of P, IC, AF and other consumer categories. All initial data were reported separately by catchment area (11 regions). The statistical summary described in Table 1 shows the minimum, maximum, mean and median values calculated between the 11 regions. Also calculated in the last column is the sum of water volumes for all 11 regions for each category of consumers. The unit of measurement used is thousand cubic metres.

Table 1. Statistical summary for cumulative data from 2016-2020 on water distribution in Romanian river basins (thousand cubic metres)

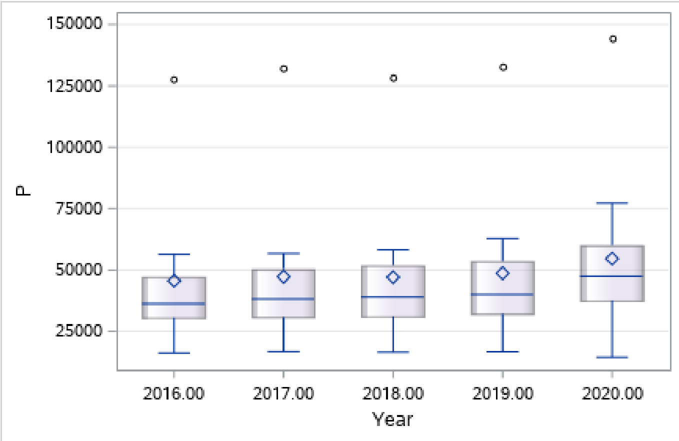
Year	N Obs	Variable	Mean	Minimum	Maximum	Median	Sum
2016	11	P	45593.72	16206.3	127485.1	36223.1	501530.9
		IC	16007.08	2523.4	43046.6	12717.2	176077.9
		AF	22520.43	123	131742.3	8374.2	247724.7
		T	93695.14	21373	229992.2	64013.5	1030647
2017	11	P	47247.55	16794.5	131667.4	38139.1	519723.1
		IC	16258.88	2676.6	50328.1	11326.2	178847.7
		AF	30151.65	105.4	148357	9051.1	331668.1
		T	102313.5	22677.7	232525.4	80311.9	1125448
2018	11	P	47073.31	16531.3	128003.7	38961.7	517806.4
		IC	14471.81	1817.7	51239.6	10378.4	159189.9
		AF	34405.65	125	192727.8	11473.8	378462.1
		T	104793.8	22034.3	279052	84130	1152732
2019	11	P	48687.04	16725	132552.9	40052.6	535557.4
		IC	14968.02	2511.2	50844.9	10989.3	164648.2
		AF	40244.05	105	223880.4	14667	442684.5
		T	112305.6	22107.2	308315	83131.6	1235362
2020	11	P	54597.65	14372.8	143726.6	47446.8	600574.1
		IC	18898.71	2202.5	57759.5	11202.1	207885.8
		AF	79490.74	1.3	421998.2	36075.8	874398.1
		T	161360	19016	560983.1	100082.5	1774960

Source: Own statistical processing using SAS Studio of data provided by the National Institute of Statistics of Romania

Water distribution to the population. Following the statistical data, the boxplot in Figure 1 shows the position on the axis of the minimum, maximum, median and mean values of the data for the 11 river basin regions in Romania. A direct analysis shows a slightly increasing trend of the median and mean values in the years 2016-2020 with the values of 2020 having the highest increase.

The assessment of differences was done for the same regions but measured at different times. For this purpose, ANOVA with repeated measures, test for equal means was used, which is the null hypothesis. The significance threshold chosen is $\alpha=0.05$. The differences have statistical significance, the values $F=8.703$, $p<0.001$ induce the rejection of the null hypothesis. In addition, the Friedman nonparametric test, test for equal medians, was used. The $\chi 2$ value=25.018, with $p<0.001$ also indicates significant differences between the volume of water consumed per year during 2016-2020.

Evaluation of differences between the determined pairs of years was done using Tukey's pairwise. Table 2 shows the test values placed below the main diagonal respectively the p probabilities placed above the main diagonal. Note the high p-probability values for the pairs of statistical data determined between the years 2016, 2017, 2018 and 2019.



Source: Own processing using SAS Studio of data provided by the National Institute of Statistics of Romania

Figure 1. Boxplot diagram on the evolution of the volume of water distributed to the population in Romania, during the years 2016-2020, recorded annually by river basin (thousand cubic metres)

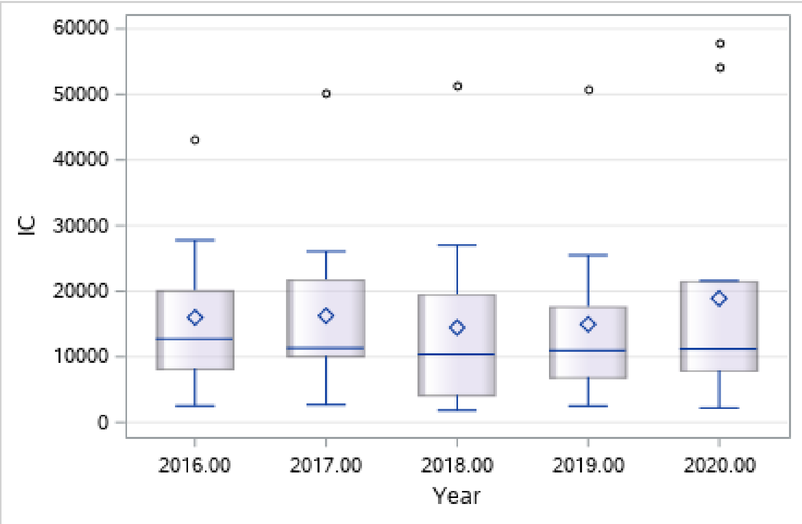
*Table 2.*Tukey's pairwise estimates for population water distribution between years 2016-2020

Tukey's pairwise	P_2016	P_2017	P_2018	P_2019	P_2020
P_2016		0.8609	0.9025	0.3655	3.58E-05
P_2017	1.392		1	0.9109	0.000771
P_2018	1.245	0.1466		0.8712	0.000563
P_2019	2.603	1.211	1.358		0.00921
P_2020	7.576	6.185	6.331	4.973	

Source: Own processing using Past 4.03 of data provided by the National Institute of Statistics of Romania

In all cases they exceed the 0.05 threshold, which indicates that there are insufficient arguments to reject the null hypothesis. The differences in the volume of water distributed that period are not statistically significant. However, the data changes in 2020 because in all pairs 2016-2020, ..., 2019-2020 the differences have statistical significance, $p<0.05$. The year 2020 showed a water volume determined for the sum of all regions of more than 600 000 thousand m3 compared to annual values in the range 501 000 - 536 000 thousand m^3 for the period 2016-2019 calculated annually. An increase of about 1.52% in the number of connected consumers is noted, from about 13.72 to 13.93 million people connected between 2019 and 2020. However, only between 2019 and 2020 the volume of water distributed to the population increases from about 535,000 thousand m^3 to more than 600,000 thousand m^3, i.e. an increase of more than 12%. Since March 2020, successive lockdown periods have most likely contributed to the increase in the volume of water distributed to the population.

Water distribution in industry and construction. A similar analysis was carried out to characterise the evolution of the volume of water distributed in the industrial and construction sector in Romania. The boxplot in Figure 2 shows an alternating evolution of the mean and median values of the volume of water distributed to the 11 regions.



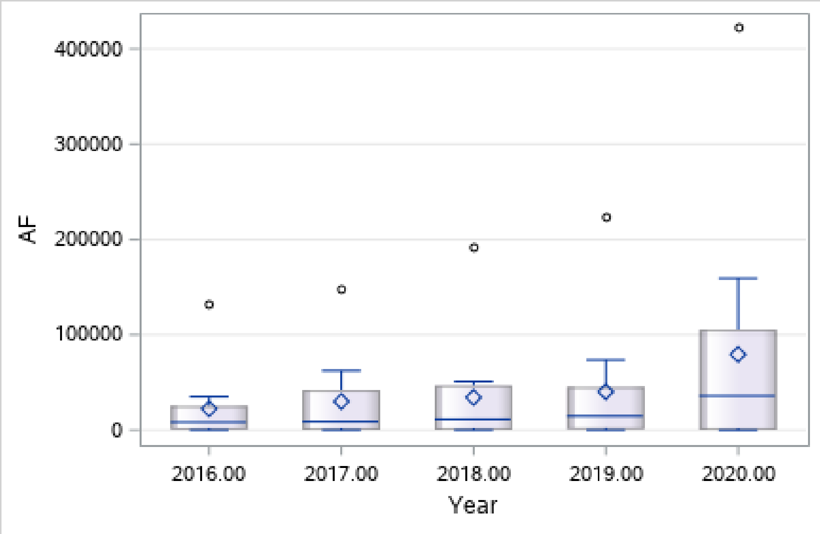
Source: Own processing using SAS Studio of data provided by the National Institute of Statistics of Romania

Figure 2. Boxplot diagram on the evolution of water distribution in the industry and construction sector in Romania during 2016-2020, recorded annually by river basins (thousand cubic metres)

ANOVA with repeated measures, test for equal means, does not lead to statistical arguments for rejecting the null hypothesis, $F=0.791$, $p<0.538$. Thus, the differences between years in the volume of water distributed on the 11 Romanian river basins in industry and construction are not significant.

In addition, the Friedman nonparametric test for equal medians indicates $\chi2=2.909$, $p<0.580$, also not significant differences. Even if the summed value of water consumption for all 11 regions is visibly higher in 2020 compared to 2019, this is due to high local values (Argeș-Vedea, Buzău-Ialomița basins) where the industrial and construction sector benefited from a high volume of water, over 54 000 thousand m^3 water while the mean and median values do not differ significantly, in other regions there were even reductions in water distribution.

Water distribution agriculture and fish farming. Data on water distribution in agriculture and fish farming, by minimum, maximum, mean and median values are shown in the boxplot in Figure 3. Of note is a slight increase in mean and median values over the 5-year period especially in the year 2020.



Source: Own processing using SAS Studio of data provided by the National Institute of Statistics of Romania

Figure 3. Boxplot diagram on the evolution of the distribution of water used in agriculture and fish farming in Romania during the years 2016-2020, recorded annually by river basin (thousand cubic metres)

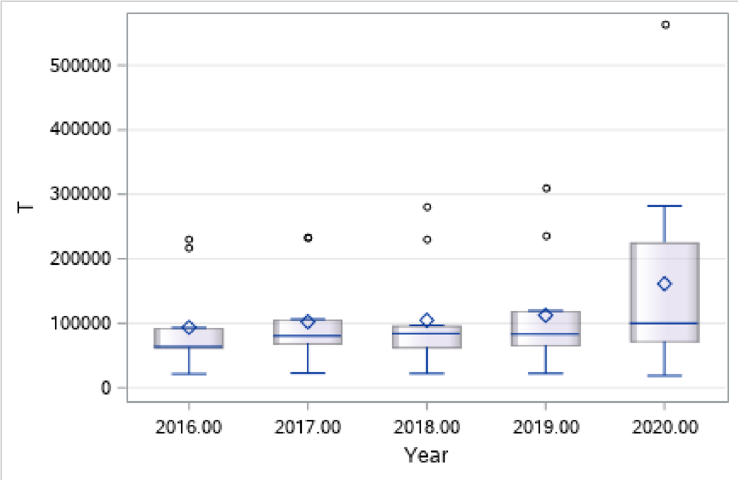
ANOVA with repeated measures, test for equal means, leads to values F=4.301, p=0.005 which indicates rejection of the null hypothesis so between the groups formed by the values of water volumes distributed in the Romanian river basins, recorded annually between 2016-2020 there are significant differences. Tukey's pairwise comparisons shown in Table 3 indicate small changes without statistical significance between the groups formed by the years 2016, 2017, 2018 and 2019. Statistically significant differences appear, however, in the year 2020 compared to each of the years 2016, 2017, 2018 separately, where all p-values are lower than the 0.05 threshold. And Friedman test for equal medians, leads to statistically assured differences between groups $\chi 2=15.782$, p=0.003.

*Table 3.*Tukey's pairwise estimates for agricultural and fish farming water distribution *between years 2016-2020*

Tukey’s pairwise	AF_2016	AF_2017	AF_2018	AF_2019	AF_2020
AF_2016		0.9867	0.9342	0.7698	0.004797
AF_2017	0.7106		0.9986	0.9628	0.01884
AF_2018	1.107	0.3961		0.9952	0.03817
AF_2019	1.65	0.9398	0.5437		0.09267
AF_2020	5.305	4.594	4.198	3.655	

Source: Own processing using Past 4.03 of data provided by the National Institute of Statistics of Romania

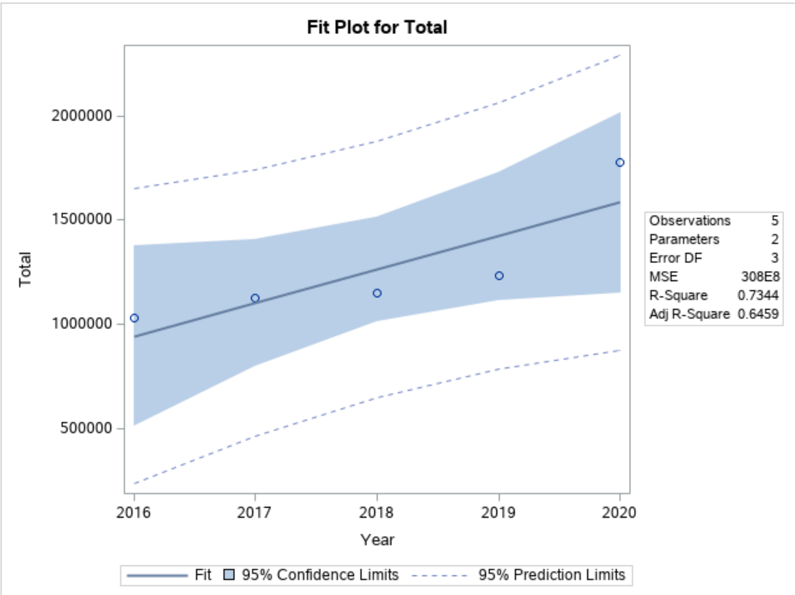
Total volume distributed. Summing up all the regional values of the total volume of water distributed, the trend is upwards. In 2016 the total volume was 1030647 thousand m^3, reaching 1774960 thousand m^3 in 2020. The average value is 1 263 830 thousand m^3 and the median 1 152 732 thousand m^3. The boxplot in Figure 4 shows the total values distributed by river basins, where the minimum and maximum values, the mean and median values for the 11 regions and their evolution over the 5 years are shown.



Source: Own processing using SAS Studio of data provided by the National Institute of Statistics of Romania.

Figure 4. Boxplot of the evolution of total water distribution in Romania during 2016-2020, recorded annually by river basins (thousand cubic metres)

Furthermore the regression line as a function defined over the interval 2016-2020, which has as values the total volume of water distributed at national level, is represented in Figure 5.



Source: Own processing using SAS Studio of data provided by the National Institute of Statistics of Romania

Figure 5. Regression line for the evolution of the total amount of water distributed annually in Romania in the period 2016-2020

As above, ANOVA with repeated measures was used as a test for equal means, indicating statistically significant differences between years, $F=4.609$, $p=0.003$. Also Friedman, Test for equal medians, leads to values with differences between years of total water consumption, statistically significant, $\chi2=22.4$, $p<0.001$. The evaluation of pairwise differences between years is reported in Table 4. The year 2020 brings statistically significant changes compared to 2016, 2017, 2018 regarding the total volume of water distributed in Romania. At the same time the pairs of years 2016 to 2019 do not show significant changes.

Table 4. Tukey's pairwise between years evaluations for total water distribution in Romania, period 2016-2020

Tukey's pairwise	T_2016	T_2017	T_2018	T_2019	T_2020
T_2016		0.988	0.9696	0.8286	3.82E-03
T_2017	0.6901		0.9999	0.9793	0.0147
T_2018	0.8887	0.1986		0.9929	0.02121
T_2019	1.49	0.8001	0.6015		0.06009
T_2020	5.418	4.728	4.529	3.928	

Source: Own processing using Past 4.03 of data provided by the National Institute of Statistics of Romania

CONCLUSIONS

The volume of water distributed in Romania through the public water supply system has recently shown a slight upward trend in terms of value for the population. In agriculture and fish farming the water distributed in the last 5 years has also shown a slightly increasing trend. The total volume of water distributed in Romania is also showing a similar trend. However, in the three situations mentioned above, the increase in the volume of distributed water has statistically significant values only in the year 2020. An alternating and mathematically uncertain trend in the evolution of water distribution is found in the industrial and construction sector in Romania.

Acknowledgments

Statistical data provided by the National Institute of Statistics of Romania are very important in understanding social or economic phenomena. The quality of these data is to be appreciated.

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IMPROVING WEATHER FORECAST ACCURACY USING THE DOPPLER RADAR – CROSS REFERENTIAL ANALYSIS OF THE 2018 CONVECTIVE SEASON AND THE IMPACT ON AGRICULTURE

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ABSTRACT

The violent manifestations of meteorological events and the increase in both frequency and intensity due to climate change have led to the need for real time monitoring of such events. The main task of the operational meteorology is to ensure the spread of correct and on time information, in order to limit the damage caused by violent outburst of weather-related events and to determine the location and severity of such events. The development of strategies for both population warning and well-being as well as for other need, as for agriculture protection is needed. The aim of this paper is to present the analysis of some events which occurred in the Western part of Romania in the time scale May to July 2018 in terms of both development and consequences and to compare and contrast some strategies for better coping with such weather events in agriculture and agriculture-related areas. By analysing the synoptic situation, together with the instability indexes and with the weather radar images, meteorologist and agricultural engineers can better understand and predict the types of hazards that may appear in an area and, as such, take precautionary measures in order to minimize the impact of severe weather on crops and farming.

Keywords: severe meteorological events, Doppler radar, meteorological warning, convective thunderstorms, meteorological forecast

INTRODUCTION

The focus on climate change and on climate change induced risks has risen in the last decade. It is now generally acknowledged that there is a strong bond between severe weather events and climate change, especially regarding the frequency and intensity (Sandu et al., 2008; Busuioc et al., 2010). The real time monitoring of weather phenomena has developed since the 1950, when the National Weather Service of the United States of America first began using weather radar devices in order to forecast heavy rainfalls, flash floods, hail and tornadoes. Weather Surveillance Radar (WSR) equipment has since developed and further developments have been implemented (Lohmann et al., 2016). The use of Next Generation Radar 98-Doppler equipment (NEXRAD 98-D) is a state of the art for operational forecasting, due to the advancements with regard to the products generated by the radar equipment.

The National Weather Service of Romania (Administrația Națională de Meteorologie) uses a network of 7 radar equipment (Mărăzan, 2018). These provide real time mosaic images for the entire country. Of real importance for agriculture is the detection of hail and severe winds.

The forecasting procedure implies not only the analysis of the weather charts for both low level and high-level conditions, but also the integration of the stability indices, which are mainly used in operational forecasting.

Severe weather affects many domains of activities and the impacts may vary. Agriculture is affected by severe weather events especially during the late spring and summer (Mircov et al., 2017). Due to the convective phenomena which occur, mainly, during the summer, events such as heavy rainfall, hailstones and strong winds are the most important events which affect agriculture.

MATERIALS AND METHODS

For the purpose of this paper, archive data regarding the weather forecasts for the 2018 convective season have been used. As such, it was established that the convective season for the year 2018 started in April and finished in September. Meteorological data has been post-processed according to the World Meteorological Organisation guidelines in order to ensure data quality and international standards (EUMETSAT, **). As such, data originated from the following weather stations: Timişoara, Jimbolia, Vărădia de Mureş, Arad and Caransebeş. Meteorological charts, which include synoptic charts, low-level jet charts, high-level jet charts and maximum wind gust charts have been analysed (Mircov et al., 2018). Of great importance in forecasting severe weather events are the 500 hPa geopotential height chart, the 850 hPa temperature chart and the 700 hPa temperature chart.

In order to be taken into account as severe weather cases, it was established that at least three of the following conditions are to be fulfilled:

1. Wind gusts exceeding 70 km/h for a timespan of more than two hours;
2. Rainfall rate at three hours shall exceed 50 l/m2;
3. Hailstones have a diameter greater than 1.5 cm;
4. Presence of a radar detected mesocyclone for more than 10 minutes;
5. Low level wind shear as diagnosed according to weather radar information.

Beside these, reports of fallen trees, reports of destroyed roofs and blocked roads have also been taken into consideration.

A distinction between forecasted alerts and nowcast alerts is to be made. As such, nowcasting is issued with the help of the atmospheric surveillance equipment, in the case of this paper, it is the weather surveillance radar. For the purpose of this paper, nowcasting alerts issued by the National Weather Service of Romania with the help of Timişoara and Oradea radars have been included into this analysis.

The use of numerical weather prediction is needed in order to better understand both the synoptic as well as the mesoscale environment (Doswell, 2001). As such, forecasters are to combine the use of mathematical models and nowcasting equipment (weather surveillance radars) in order to obtain a better characterisation of the meteorological conditions and to better understand severe weather events.

RESULTS

During the timescale April to September 2018, according to the methodology presented above, there were 24 cases of severe weather, which affected the western part of Romania. For these cases, the National Weather Service emitted mostly yellow and orange code alerts.

Figure 1 shows the number of severe weather cases during the convective season 2018, as defined in the materials and methods section. The majority of the severe weather cases occurred in May, followed by June and July, August and September.

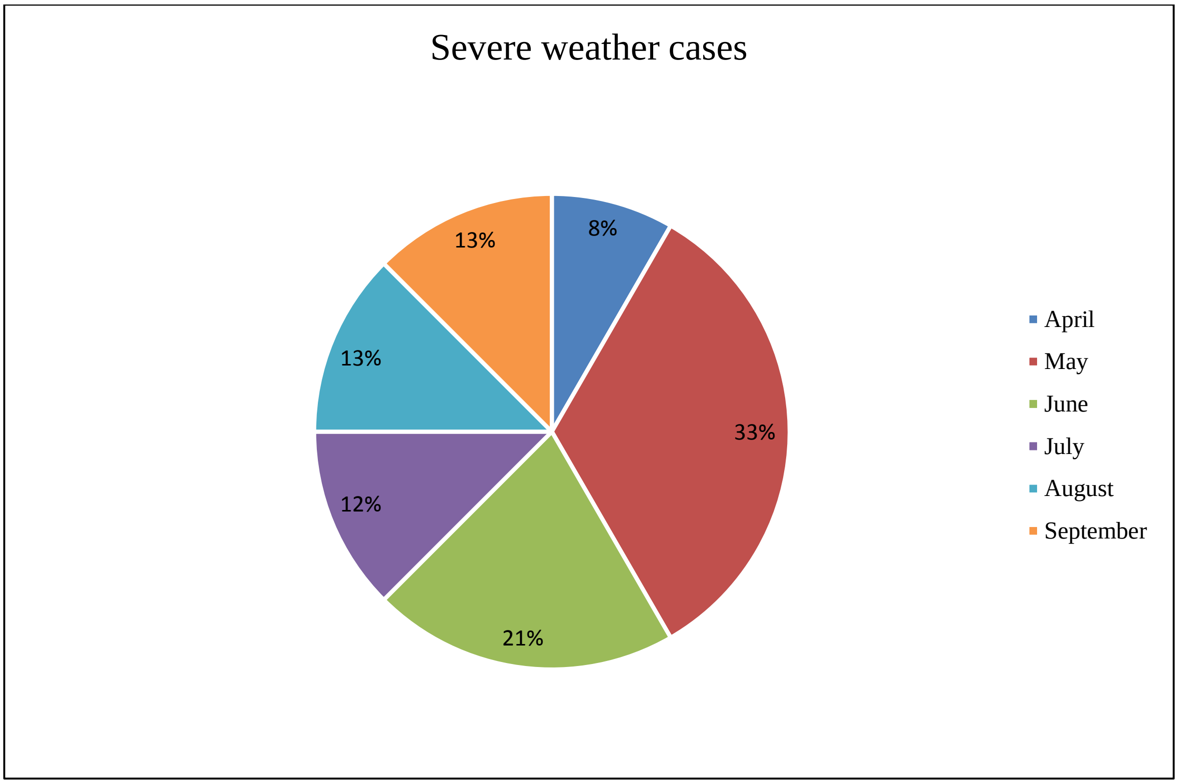

Figure 1: Severe weather cases distribution for the timescale April – September 2018

By analysing the radar structures of the above-mentioned severe weather events and by performing a structural analysis, it was concluded that the multi-cell cluster was dominant, followed by the single cell structures, supercell structures and squall lines. The most ordinary thunderstorms, single cell thunderstorms, also known as air mass thunderstorms are the most frequent and, as such, are the first to signal the start of the convective season (Şerban, 2010). They mainly occur during the mid to late spring months (April, May and June) and usually come to an end by the end of September. Multi cell thunderstorms are more complex because of their developing mechanism. A dissipating cell forms another convective cell and the last one reaches maturity and starts forming another cell. The process then continues for as long as there is enough energy to sustain the convection.

As it is depicted in *Figure 2*, weather forecast accuracy is largely improved due to the fact that the structures can be determined. The main difference between the results presented in figure 2 is the presence of self-sustaining lifting mechanism, as it is the case for multi cells, supercells and even squall lines.

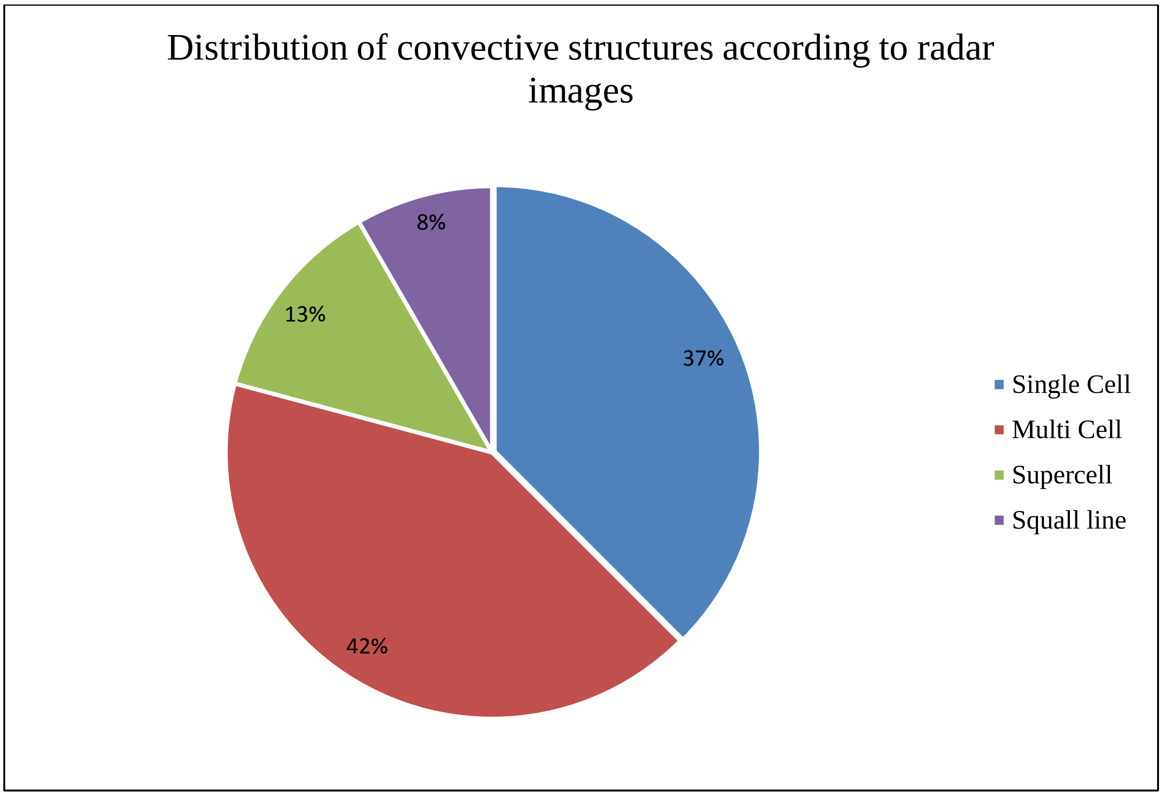

Figure 2: Distribution of convective structures according to radar images

While single cell thunderstorms are not capable of self-sustaining because of the lack of a lifting mechanism, they have the capability to produce hail with a diameter of less than 1.5 cm. Of course, if updrafts are sustained, the hailstones may reach a diameter of more than 1.5 cm. Because of the topography of the western part of Romania, single cells and multi cells account for around 70% of all convective structures. Of course, the initiation of fully grown supercells is possible, especially during hot and humid days. This unstable atmosphere triggers together with the low-level windshear the initiation of mesocyclones, vertical spinning airflows, which fuel up the storm.

As for the western part of Romania, the analysed timescale shows that the most hailstorms occurred during May (6 events) and August (4 events). This can be explained by the fact that the air masses which are transported from the northern part of Africa bring hot and dry air. Any cold air advection from the northern part of the continent causes a mixing between two different types of air and, as such, convective storms are initiated (Topor & Stoica, 1965). April, July and September have the least cases of hail storms. In the case of April and September, this may be explained by the fact that the convective season has firstly not started in a proper way and secondly that in September the amount of energy is not enough in order to initiate hailstorms.

DISCUSSION

The different growth stages are aften recognizable from the hailstone structure. However, direct observations in nature from mountain observatories or aircraft ice particles at different stages of their development more firmly establish the pattern of this evolution. Hail formation usually takes place in a cloud of supercooled water droplets that originated from condensation on cloud condensation nuclei. Ice requires not only a temperature below 0°C but also a catalyst to trigger the phase transition. The following types of ice nucleation are recognized: deposition of water vapor into the ice phase on particulate matter, condensation of vapor into the liquid phase with subsequent freezing by nucleation, activation of nuclei immersed in water droplets and contact nucleation, where nuclei collide with droplets and induce them to solidification.

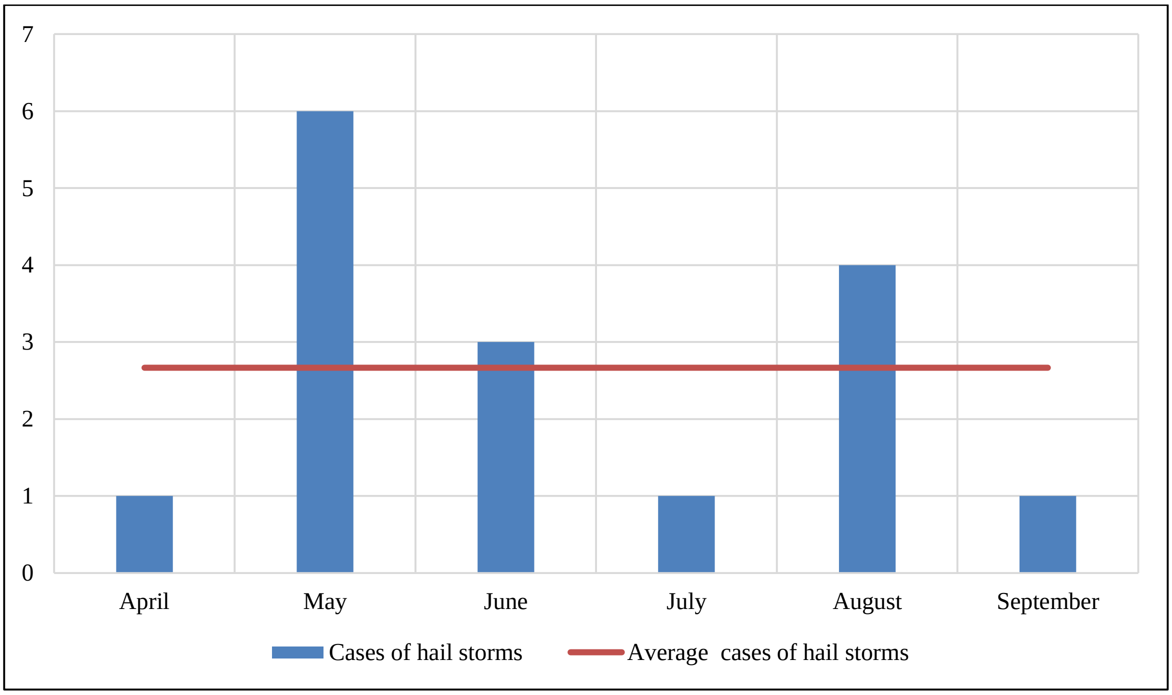

Figure 3: Monthly cases of hail storms and average cases of hailstorms for the timescale April – September 2018

The damage that hail produces to crops and to agriculture, in general, is significant. The greatest damage is done by hailstones which originate from either supercell thunderstorms or multi cell thunderstorms. These two kinds of thunderstorms have self-lifting mechanisms and are capable of sustaining the hail embryos better and for longer periods of time.

The initial thermal and fair-weather stage of the cumulus cloud is generally not detectable by conventional radars. As a towering cumulus cloud grows and large cloud droplets begin forming, however, radar reflectivity begin appearing at a height of about 3 to 5 km and increase the reflectivity from 0 to 20 dBZ. As the cumulonimbus cloud begins maturing, the moist intense core is found at the -10° to -20° C layer, as such, roughly at around 20000 feet, where supercooled drops, graupel, ice and hail are present.

Traditionally, the best method for finding hail on weather surveillance radar is to look at the lowest elevation for reflectivity with very high intensities. Reflectivities above 60 dBZ are rarely associated with rain and involve ice, which is a much better reflector.

As for mitigation methods for hailstorms, the use of cloud seeding proves to be a good method for securing the crops and the agriculture industry in the western part of Romania. The lack of specialized studies in the field of agricultural meteorology and operational agrometeorology imposes a high risk on sustainable development.

In conclusion, the use of both numerical weather prediction systems in strong bond with the nowcasting equipment (weather surveillance radars and satellite images) offer a great advantage in forecasting severe weather events, especially for the mitigation of hail storms. The launch of cloud seeding programme in Romania is currently a need because of the climate change induced weather events in order to ensure economic growth and prosperity.

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PREVENTING THE EFFECTS OF CLIMATE CHANGE BY PLANTING PROTECTIVE CURTAINS

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ABSTRACT

Global warming currently involves two major problems for mankind: on the one hand, the need to drastically reduce greenhouse gas emissions to stabilize the level of concentration of these gases in the atmosphere that would prevent anthropogenic influence on the climate system and allow ecosystems to adapt naturally, and, on the other hand, the need to adapt to the effects of climate change, given that these effects are already visible and inevitable due to the inertia of the climate system, regardless of the outcome of emission reduction actions. Protective curtains play a very important role in increasing the yield of all crops and pastures, protecting them from soil erosion, against the blizzard, and helping to reduce the effects of climate change, producing oxygen. The authors analyzed the situation of the protection curtains and concluded that we urgently need forest in the plain areas and the surrounding area of localities. We still have shade on 6% of Romania's plains, and the big cities are suffocating under pollution and heat. Afforestation of these areas is a priority objective for national security. 100 years ago we planted the first green protective barriers. We started losing them 50 years ago. It is time to rebuild the natural solution that forests offer, destroyed by ignorance, greed and mismanagement.

Keywords: climate change, prevention, effects, protective forest curtains

INTRODUCTION

Global warming is a phenomenon unanimously accepted by the international scientific community, is already highlighted by the analysis of long-term observational data.

Global warming has become, especially in the last few decades, an issue that has been on the priority list of governments around the world. Since 1990, at the political level, there has been a growing awareness of the need to make decisions that reduce the national and global impact of human activity, which leads to a rapid increase in global warming.

It has increased as a result of the increase in greenhouse gas emissions into the atmosphere, since the 1800s, immediately after the Industrial Revolution. Because the number of factories has increased and the goods produced have multiplied so far, the levels of pollutants in the atmosphere have reached, in just a few hundred years, higher levels than in all previous human evolution (Vass H. et. al 2020).

The average global air temperature has increased by about 0.74ºC in the last 100 years (1906 -2005) compared to 0.6ºC in 1901-2000. 11 of the last 12 years have been the warmest in the 1850 data series. (The Intergovernmental Panel on Climate Change, 2022).

Compared to the increase of the global average annual temperature of 0.6ºC during the period 1901-2000, in Romania, the annual average registered an increase of only 0.3ºC. During 1901-2006 the increase was 0.5ºC compared to 0.74ºC globally (1906-2005) (European Environment Agency 2022).

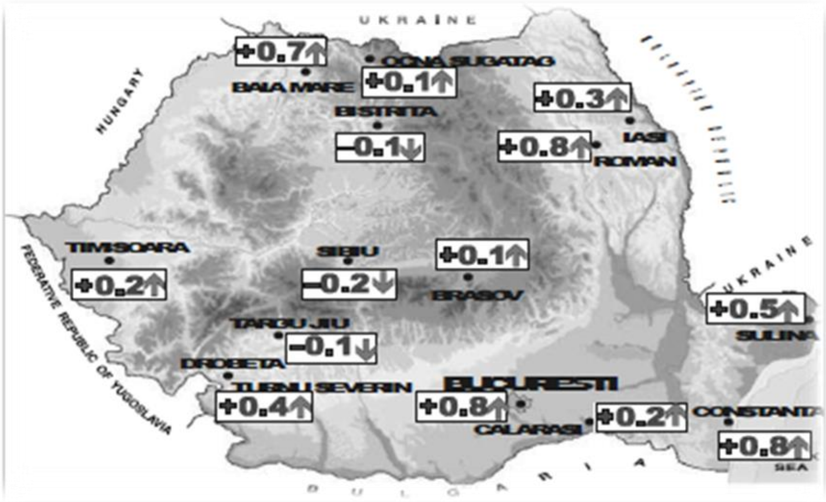

Figure 1. The trend of the average annual temperature in Romania (°C) during 1901-2000
Source: guidance on adapting to the effects of climate change

In the history of Romania, forest curtains have been a constant presence for over 150 years. The need for protective curtains was first brought to the public's attention in 1860 by Ion Ionescu de la Brad, who built the first plantations. The first proposals for the execution of protection curtains belong to B. Pizu. In 1881, in "Revista Pădurilor", he proposed the installation of 56 strips of forest, from the Danube to the vineyards, somewhere in the Bărăgan area and in the south of Moldavia. The strips of forest were to be located at a distance of about 20 km between them. Many landowners have put these projects into practice.

The positive results were not long in coming. But they were best seen in the case of the drought of 1946, the driest year of the twentieth century, when the shelter of the curtains obtained a 300% increase in yield over the unprotected field. The curtains also had a positive effect in 1947, when in Dobrogea the wheat was completely frozen in the unprotected fields, but 600 kg/ha were obtained in the shelter of the curtains. As a result, a large-scale action was launched for the creation of the curtain network in Dobrogea. The works took place between 1950 and 1961. The network occupied an area of about 3,000 ha, protecting an area of approx. 1,000,000 ha (Greenpeace, 2022).

In 1962, by a communist decree, without any scientific basis, it was decided to cut off all litter on agricultural land under "they are a Stalinist idea."

Specifically, forest curtains protect roads, stopping wind-blown snow from reaching roads. In agricultural areas, they protect crops from strong winds, maintain moisture in adjacent areas, ensure greater biodiversity and act as an additional factor in reducing nutrient pollution (Mateoc-Sîrb et. al 2016). The excess nitrogen is taken up by forest vegetation, which has deeper roots than cereals or vegetables and is metabolized to no longer reach the groundwater (Gumovschi A. 2021).

These are just a few of the many services that forestry buffer strips provide to protect agricultural land. (Ministry Of Environment, Water And Forests, 2022)

MATERIALS AND METHODS

As part of our complex concerns about climate change and the need for protective forest cover, we have had the opportunity to document ourselves from various sources in the literature, we have studied, analysed and centralised current data from national statistics, as well as much information and reports made available electronically on the website of the Ministry Of Environment, Water And Forests, the National Statistical Institute, the Food and Agriculture Organisation and the European Environment Agency, Greenpeace. We have analysed the situation of forest protection fences in Romania according to local sources and have come to multiple conclusions.

RESULTS

Sustainable agricultural performance requires *agro-protection forestry barriers*. Protective fences are strips of several rows of trees, shrubs and bushes that surround the soil of settlements, roads and household centres.

Forestry hedges play an important role in protecting crops from drought, erosion and landslides. According to studies carried out by the Food and Agriculture Organisation (FAO) in various countries, the effect of forestry fences leads to an average crop yield increase of 15% (Food and Agriculture Organisation 2022).

Forest shelterbelts reduce wind force and improve the microclimate of the fields, retain snow and prevent it from blowing off the fields, usually retain water runoff from melting snow and heavy rain, improve the hydrological regime of the land and increase the moisture of the fields, protect the soil from washout and erosion as well as deflation (Galupa D. et. al 2017).

Experimentally, it has been established that one hectare of forest or woodland during the period of active vegetation in 24 hours pumps more than 30 t of water from the soil into the air. Thus, in times of drought, the relative humidity of the air increases by several per cent.

Figure 2. 2,200 hectares of forest buffer strips rehabilitated by the Competitive Agriculture Project

Source: agrobiznes.md, 2022

In times of drought, forest strips increase the relative humidity of the air by 10% and reduce the evaporation capacity of plants by an average of 15-20%, so forest strips during the growing season save water. For example, on early spring crop sowing - 10-15 mm, sunflower - 20 mm, maize - 30 mm.

If there is no forested land near the water collectors, water run-off from the soil surface is 50-60%, if 10% of the territory is forested - 20-27%, if 30% - 15-20%, and if 50% - 13-15%.

Forestry hedges contribute to the accumulation of organic matter in the soil. On agricultural land protected by forest cover the humus content in the topsoil increased by 0.21-0.50%, in the horizon below the topsoil there is only a tendency to increase (0.09-0.07%).

In Romania, under moderate drought conditions, 43% more autumn wheat, 61% more cob maize and 28% more sunflower were obtained.

These results represent the effect of the influence of the curtains on significantly reducing wind speed in the protected field.

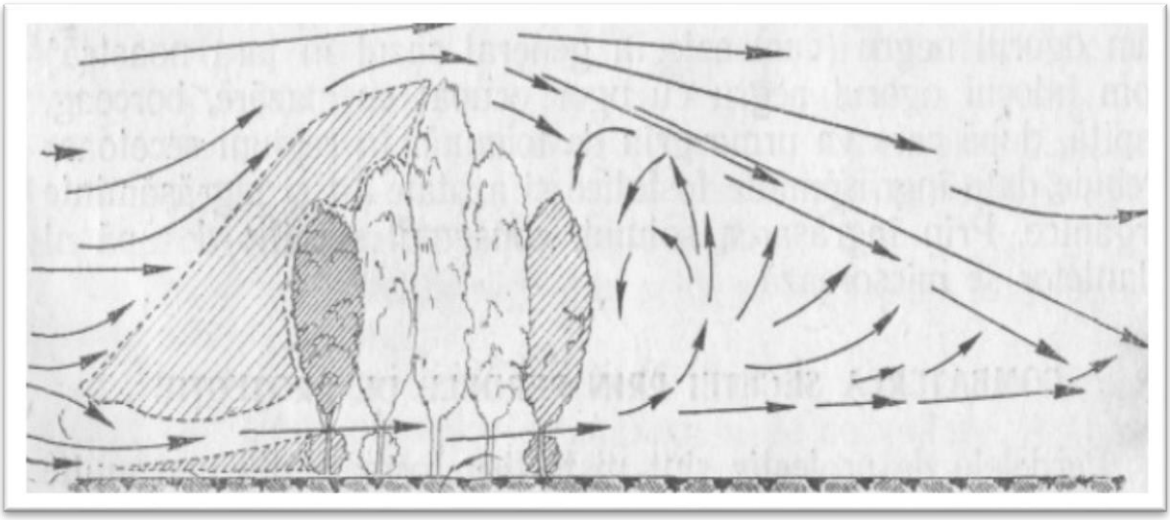

Figure 3. How the wind blows through the shelterbelts

Source: agrobiznes.md, 2022

Under irrigated conditions, forestry curtains increase productive transpiration by 13% and yield by up to 30% compared to fields irrigated but not protected by curtains.

It also reduces water consumption by 17% per ton of plant mass-produced, which means a reduction in the irrigation requirement and therefore lower costs.

In 2020, most of the regeneration, respectively 99.6% was carried out on land in the forest, 0.3% on land outside the forest and 0.1% on land outside the forest estate.

It can be seen that of the total regeneration carried out from 2011 to 2022, the share of forest protection curtains, field protection curtains are very small, even non-existent in several years (Table 1).

Table 1. Regenerated areas, by category of land, over the period 2011 – 2020 in Romania

- hectares -

Categories of Land / Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Regenerations - total	***25000***	***25727***	***26285***	***29505***	***28750***	***28456***	***28032***	***27043***	***24459***	***25189***
In forestry	**23832**	**24706**	**25750**	**27074**	**28163**	**27845**	**27789**	**26971**	**24258**	**25083**
forest protection curtains	-	-	-	-	-	4	-	-	-	3
On land taken into forestry land	**425**	**171**	**33**	**76**	**62**	**1**	**8**	**30**	**72**	**20**
forest protection curtains	-	-	-	23	-	-	-	7	68	17
On land outside the forest estate	**743**	**850**	**502**	**2355**	**525**	**610**	**235**	**42**	**129**	**86**
field protection curtains	33	173	96	104	-	-	-	-	-	-

Source: Statistics on forestry activities in 2020, insse.ro

Table 2. Areas with forest vegetation deficit and afforestation availability in Romania

No.	County	%
1	București	3
2	Călărași	4
3	Teleorman	5
4	Brăila	6
5	Constanta	6
6	Ialomița	6
7	Galați	8
8	Olt	10
9	Botoșani	11
10	Giurgiu	11
11	Tulcea	12
12	Dolj	12
13	Timiș	12
14	Vaslui	14
15	Satu Mare	16
16	Ilfov	16
17	Iași	18
18	Cluj	24
19	Sălaj	25
20	Buzău	26
21	Arad	27
22	Bihor	28
23	Dâmbovița	29

Source: Statistics on forestry activities in 2020, insse.ro

Since 2016, following the amendment and completion of the Law no. 46/208 - Forestry Code, forest deficit areas are those counties in which the area of the forest fund represents less than 30% of its total area.

In Romania 23 out of 41 counties have a deficit in this respect (Table 2).

For the next period, it is planned to increase the area of forest vegetation, with priority in these counties, by afforestation of degraded land unsuitable for agriculture and by afforestation for the implementation of the National System of Protective Forest Fences.

The main effects of the installation of forest protection fences bring the following benefits:

- improvement of microclimatic conditions (modification of albedo, reduction of diurnal and annual air temperature amplitude, reduction of wind speed, retention of snow, reduction of evapotranspiration, increase of air humidity);
- reduction of the diurnal air temperature range by 1-4°C and of the annual air temperature range by 1-2°C, reduction of wind speed by 31-55% in the sheltered part and by 10-15% in the exposed part, reduction of non-productive evapotranspiration by up to 30%, an increase of surface air humidity by 3-5%;
- improving the growing and development conditions of adjacent crops up to 20-30 times the height of the canopy on the leeward (sheltered) side and 5-12 times the height of the canopy on the windward (exposed) side;
- increasing soil fertility and conservation conditions, reducing erosion and water run-off on slopes, reducing to complete halt defoliation, increasing soil moisture, enriching the soil with humus and other nutrients and changing its pH due to the surplus of organic matter in leaves and roots;
- Carbon storage. Every 1000 ha of planted forest canopy stores about 50 tonnes of CO_2 at the age of 20 years, which increases with the age of the trees.
- Oxygen release from trees. Under optimal ecological conditions, a leaf area of 25 m^2 can release as much oxygen as a human needs in the same unit of time.
- Studies in the USA have calculated that during a growing season 1 m^2 of leaf area releases, depending on the species, from 0.47 kg oxygen to 1.1 kg oxygen.
- One hectare of forest plantation absorbs 8 kg of carbon dioxide in 8 hours, about the same as 20 people exhale in the same period. According to World Health Organisation standards, to provide an optimal annual per capita oxygen supply of 400 kg, a green area of 0.1-0.3 ha is needed.
- increased production of wood and by-products;
- increasing the area covered by forest vegetation;
- protection of economic and social objectives and communication routes;
- creating favourable conditions for the development of local fauna;
- increasing local biodiversity;
- improving the carbon stock;
- reconstruction and improvement of the landscape

DISCUSSION

In the next 30 years, more than 40% of Romania will become an arid steppe. Climate modellers' modelling indicates that, in a moderate scenario, more than 11 million Romanians will be affected by rising temperatures, drastically reduced water supplies and desertification.

Drought will become the new normal. The National Meteorology Administration has issued 132 Reds Codes in the summer of 2020, the most in meteorological history (Administrația Națională de Meteorologie 2022). The climate crisis is not bypassing Romania. We have little time left to prepare a defence. It's not enough to protect our remaining forests in the mountains, which are also heavily affected by illegal logging. We need a national forest network to protect our cities, our most vulnerable communities and our farmland.

Romania had a network of hundreds of thousands of hectares of forests and forest canopies in the south and southeast of the country, part of an ambitious drought protection plan. These have been cleared since the 1960s in the name of agrarian policies harmful to the soil and the environment. In the 1990s, irrigation systems were destroyed and the tree stands that still protected fields and roads became firewood. Illegal logging in recent years has officially surpassed the worst estimates: 20 million cubic metres of timber disappear without a trace every year, including from the lowland areas most affected by deforestation.

Figure 4. Forestry fences planted by Romanians in the former Cadrilater and preserved by Bulgarian neighbours. The network extending into southern Romania was razed. RO-BG border, 2020.

Source: Greenpeace.ro, 2022

Climate change is already here. Without forests, the entire lowland area of Romania, the breadbasket of Europe, is rapidly drying up. 11 million Romanians are directly affected. In the last decade alone, Romania has paid €330 million in compensation to farmers affected by drought, enough to surround the planet with forestry curtains around the equator.

We urgently need forests in lowland areas to stop soil erosion and provide food. In 2020, people's wells have been running dry since the beginning of summer, and by the end of August, we started counting evaporated lakes.

Only 6% of Romania's plains are still shaded, and big cities are choking under pollution and heat. Reforestation of these areas is a priority for national security. 100 years ago we planted the first green protective barriers. Fifty years ago we were starting to lose them. It's time to rebuild the natural solution provided by forests, destroyed by ignorance, greed and mismanagement.

Without global action to limit emissions, the IPCC expects global temperatures to rise another 1.8 to 4.0ºC by 2100. This means that the temperature increase since pre-industrial times would be over 2°C. Above this threshold, irreversible and possibly catastrophic changes are far more likely to occur.

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ANALYSIS OF INVESTMENTS FOR ENVIRONMENTAL PROTECTION AND SUSTAINABLE ECONOMIC DEVELOPMENT

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ABSTRACT

The paper aims to analyze the investments for environmental protection starting from the fact that the synergy between the environment and economic growth is the premise for the sustainable economic and social development of the country.
Sustainable development also involves economic growth, without which resources for environmental protection cannot be obtained. In order to achieve the goals of sustainable development, progress is needed in all four dimensions: economic, socio-human, ecological and technological. This implies the realization of a complex and comprehensive strategy for sustainable development through an integration of economic policies, research and technological development, environmental protection, investment and employment.
The research is based on statistical information obtained from the National Institute of Statistics. In conclusion, during the analyzed period, there is an increase in investments for environmental protection, but this is not followed by an increase in environmental effects.

Keywords: investments, environmental protection, producer categories, environment

INTRODUCTION

Since 1992, the Earth Summit in Rio de Janeiro has highlighted the need for sustainable development of society, reiterated at the World's Summit on Sustainable Development in Johannesburg (Snack et al. 2001). If the environment is not protected, we cannot ensure sustainable development. Environmental protection influences sustainable development, and sustainable development encompasses environmental protection.

Environmental protection encompasses a multitude of actions: rational management of resources, avoiding imbalances by caring for nature conservation, preventing environmental pollution, as well as its ecological restoration. Environmental protection measures include „establishing an obligation, setting special conditions and prohibiting the irrational use of natural resources, preventing and combating environmental pollution and the harmful effects of natural phenomena on its components". These measures are meant to maintain the ecological balance with a view to ensuring better living and working conditions for future generations (Kaposta 2009; Vişan et al. 2000; Sîrbulescu 2021).

Environmental protection activities are directed to better maintenance of a clean environment by collecting-recycling-treating waste, reducing pollutants identified in the environment or by preventing emissions of pollutants and noise (Sîrbulescu 2021; Frăsineanu and Băloiu 2007).

By analyzing the expenditures for the environmental field, one can evaluate the effort for the prevention, reduction and elimination of pollution as a result of the production and consumption of products and services.

The category of environmental expenditures includes investments, along with the current expenditures of the public administration and non-specialized and specialized producers.

The motivation for choosing this theme was the fact that a clean environment is the basic element in ensuring working and living conditions.

The objective of the article is the analysis of investments for environmental protection, the component of total expenditures for environmental protection.

Sustainable development is the form of economic growth that ensures the satisfaction of society's needs in terms of welfare in the short, medium and long term, and it must meet the needs of the present, without endangering those of future generations.

This concept reconciles between the environment and the economy, constituting the path of development that supports human progress for the entire planet and for a long future. The compatibility of the four systems must be ensured: economic, human, environmental and ecological, so as to ensure that the needs of the present are met, without compromising the ability of future generations to meet their own needs. Sustainable development strategy includes simultaneous progress in all four dimensions (Bari 2001).

The concept of sustainable development is the solution to the situation of environmental degradation, as a result of human activity. Environmental damage will have a profound negative impact on future generations. Environmental degradation is often accompanied by economic growth (Antoci et al. 2005; Shadbegia and Wayne 2005), driven by the development of economic activities. However, the increase in economic activities leads to an increase in carbon dioxide emissions (Adewuyi 2016; Mesjasz-Lech 2017) and other pollutants. It is noteworthy that the demand for a quality environment is constantly growing (Thiene et al. 2017; Ghereş et al. 2010), and companies cover the costs of environmental protection with the certainty that the positive effects of these activities are greater than the costs (Rogers et al. 1997).

According to other authors, sustainability is „the state of balance in which there is harmony between the activities of the population and their natural, social and cultural environment” (Middleton and Hawkins 1998).

Sustainability includes „a set of approaches aimed at preventing the negative economic, social and environmental effects that result from human actions on environmental resources and that occur on long term” (Coccossis 1996).

The most well-known definition of sustainable development is the one given by the World Commission on Environment and Development (WCED) in the report „Our Common Future" also known as the Brundtland Report: „Sustainable development is development that seeks to meet the needs of the present without compromising the possibility for future generations to meet their own needs” (Sustainable Romania. National indicators for sustainable development Horizon 2020).

MATERIALS AND METHODS

For the article we used specialized literature that includes books (Ghereş et al. 2010 Frăsineanu and Băloiu 2007; Snack et al. 2001), monographs (Antoci et al. 2005; Adewuyi 2016; Mesjasz-Lech 2017; Middleton and Hawkins 1998; Rogers et al. 1997; Shadbegia and Wayne 2005; Sîrbulescu 2021), but also statistical data (INS 2017-2021) on investments for environmental protection that have been analyzed, interpreted and presented in the form of tables and figures.

The data used were collected from the Statistical Information-Expenditures for environmental protection, in the period 2016-2020 and Press Releases - Expenditures for environmental protection, in the period 2016-2020 of the National Institute of Statistics of Romania (INS 2017-2021).

The scientific research method consisted in a comparative analysis of investments for environmental protection by the main categories of producers (public administration, non-specialized and specialized producers), in the period 2016-2020.

Each of these categories is composed of units specific to those activities. Thus, the category of specialized producers includes: units for wastewater collection and treatment; units for waste collection, treatment and disposal, recyclable materials recovery activities; units for decontamination services and units engaged in the wholesale trade of waste and scrap (INS 2021).

The category of non-specialized producers includes: forestry units, economic units in the extractive industry, processing, producing and supplying the electricity and heat, gas, hot water and air conditioning; water collection, treatment and distribution units; construction units and transport units. In the category of the public administration sector are the central and local public administration units.

Public Administration includes all local and central public administration units that produce or finance non-commercial environmental protection services, intended for individual and collective consumption (INS 2021).

Investments in environmental protection include „expenses incurred for construction, installation and assembly works, for the purchase of equipment, means of transport, other expenses for the creation of new fixed assets for the development, modernization, reconstruction of existing ones, in order to protect environment". To these are added „the value of services related to the transfer of ownership of existing fixed assets and land (taxes, materials, commissions, loading-unloading transport costs)" (INS 2021).

Investments for added technical means (investments for pollution treatment) - investments in equipment located at the end of the production process, which consist of installations or parts of installations, for use in the context of environmental protection. These plants operate independently of the production process and have the role of treating the pollution already generated (e.g. emissions) or measuring the level of pollution.

Investments for integrated technical means (investments for pollution prevention) - investments in integrated technologies that represent adapted installations or parts of installations, in order to reduce the amount of pollution generated. Because these equipments are integrated in the production process and cannot be identified as separate parts, the cost will be estimated either as a cost difference compared to an available alternative or based on the weight of the costs of the environmental components in the total costs (INS 2021).

RESULTS

Romanian society and humanity in general face, among other things, two important issues, pollution and environmental protection. Global transformations in the quality of the environment involve the discovery of solutions to ensure the maintenance of the global ecological balance, in the conditions of sustainable development.

In 2020, the expenditures on environmental protection amounted to approximately 16 billion RON, representing approximately 1.5% of the Gross Domestic Product, according to data provided by the National Institute of Statistics (INS).

Table 1. The share of investments and current domestic expenditures for environmental protection at national level in the Gross Domestic Product (%)

	2016	**2017**	**2018**	**2019**	**2020**
Investments	0.4	0.3	0.4	0.3	0.3
Internal current expenses	0.8	0.8	0.8	0.8	0.8

Sources: www.insse.ro

In order to avoid double recording that may occur when aggregating data at the national level, the calculation of total expenditures included, in addition to investments, current internal expenditures and other public administration expenditures (grants awarded, transfers) and excluded external current expenditures (Table 1).

The share of investments for environmental protection at national level, in the Gross Domestic Product (Table 1), decreased from 0.4%, in 2016, to 0.3%, in 2020.

The analysis of investments for environmental protection by activity sectors (Table 2) shows that in the analyzed period there was an increase of 563,372 thousand RON current prices from 3,004,455 thousand RON current prices, in 2016, to 3,567,827 thousand RON current prices, in 2020.

The largest investments by activity sectors in non-specialized producers were registered in the „Extractive industry" sector, in 2018, of 855,702 thousand RON current prices and in the sector „Water capture, treatment and distribution" of 581,668 thousand RON current prices, in 2016.

In 2020, by sectors of activity, non-specialized producers recorded the largest investments in the sector „Water capture, treatment and distribution", representing 31.26% of total environmental investments in this category of producers, followed by investments of 23.37% in the „Extractive industry" sector.

The share of investments for environmental protection by categories of producers (Table 3) differs from one year to another, in the period 2016-2020. In 2020, the largest investments were made by the public administration, 54.5% of the total, followed by the investments of non-specialized producers of 31.0% and the investments of specialized producers, 14.5%. In 2020, at national level, investments in environmental protection accounted for 27.0% of total environmental expenditures, up from 2019 when they accounted for only 22.4%.

Table 2. Investments for environmental protection by activity sectors

- RON thousand current prices-

Years / Activity sectors	2016	2017	2018	2019	2020
Unespecialized manufacturers	**1,233,658**	**887,667**	**1,657,409**	**1,174,478**	**1,109,693**
Forestry, logging and related services	13,052	6,168	2,587	2,490	364
Extractive industry	203,350	146,258	855,702	519,081	259,446
Manufacturing industry	174,640	191,892	123,934	203,085	185,994
Production and supply of electricity and heat, gas and hot water	134,888	129,976	254,361	80,250	226,787
Water capture, treatment and distribution	581,668	234,235	261,596	217,021	346,938
Construction	5,058	7,353	11,149	24,871	6,667
Transport	121,002	171,678	145,462	126,534	83,453
Other activities	0	107	2,618	1,146	44
Specialized manufacturers	**285,600**	**266,043**	**400,913**	**446,773**	**517,931**
Public Administration	**1,485,200**	**1,152,299**	**1,434,900**	**1,951,400**	**1,951,400**
Total	**3,004,455**	**2,306,009**	**3,493,222**	**3,572,651**	**3,567,827**

Sources: www.insse.ro

Table 3. The distribution of investments for environmental protection by producer categories (%)

Categories of producers	2016	2017	2018	2019	2020
Unspecialized manufacturers	41.1	38.5	47.4	32.9	31.0
Specialized manufacturers	9.5	11.5	11.5	12.5	14.5
Public Administration	49.4	50.0	41.1	54.6	54.5

Sources: www.insse.ro

During the analyzed period, the highest increase of investments for environmental protection in environmental fields (Table 4) was registered in the field of wastewater management, followed by waste management, but also the protection of the surrounding air and climate.

At national level in 2020, of the total investments for environmental protection in environmental fields, the most of it was invested for wastewater management, representing 54.9% of the total, followed by waste management, 23.9% and environmental protection and of climate, 12.1%

Table 4. Investments for environmental protection, by environmental domains

- RON millions current prices

Environmental domains	2016	2017	2018	2019	2020
Protection of the surrounding air and climate	306.1	204.7	907.2	547.0	432.5
Wastewater management	1543.0	1051.4	1398.8	1850.8	1960.3
Waste management	822.5	660.2	768.0	855.9	852.5
Protection and remediation of soil, groundwater and surface water	192.7	175.4	177.8	209.6	203.8
Biodiversity and landscape protection	14.7	8.7	13.2	4.7	5.7
Other environmental areas	125.3	205.6	228.3	104.6	113.2
Total	3004.5	2306.0	3493.2	3572.7	3567.8

Sources: www.insse.ro

Regarding the investments for environmental protection of non-specialized producers in environmental fields (Table 5) in the period 2016 - 2020, the largest investments were made in the field of „Protection of the air and climate" with an average over the entire analyzed period of approximately 459,031 thousand RON, followed by the field of „Wastewater management" with an average of approximately 372,444 thousand RON.

During the analyzed period, the largest investments of specialized producers (Table 6) were registered in the field of „Waste management", 199,750 thousand RON, from 282,420 thousand RON, in 2016, to 484,170 thousand RON, in 2020, followed by the field of „management wastewater", of 12,460 thousand RON from 1,431 thousand RON, in 2016, to 13,891 thousand RON, in 2020.

Table 5. The distribution of investments for environmental protection of non-specialized producers by environmental fields

- RON thousand current prices--

Environmental domains	2016	2017	2018	2019	2020
Protection of the surrounding air and climate	265,822	197,137	895,974	536,068	400,152
Wastewater management	599,998	287,780	298,423	294,622	381,396
Waste management	57,908	69,141	90,479	69,876	75,201
Protection and remediation of soil, groundwater and surface water	190,600	166,567	173,882	204,607	199,218
Biodiversity and landscape protection	14,736	8,680	13,105	4,537	5,584
Other environmental areas	104,593	158,362	185,546	64,768	48,142

Sources: www.insse.ro

Table 6. The distribution of investments for environmental protection of producers specialized in environmental field

- RON thousand current prices-

Environmental domains	2016	2017	2018	2019	2020
Protection of the surrounding air and climate	68	33	3,454	2,888	6,295
Wastewater management	1,431	6,729	9,435	7,078	13,891
Waste management	282,420	257,167	386,796	436,356	484,170
Protection and remediation of soil, groundwater and surface water	163	1,632	62	338	1,565
Biodiversity and landscape protection	0	0	12	40	5
Other environmental areas	1,516	482	1,154	73	12,005

Sources: www.insse.ro

The analysis of the investments for environmental protection of the public administration by environmental domains (Table 7) shows that the largest investments were registered in the field of „wastewater management" (607,500 thousand RON from 941,600 thousand RON, in 2016 to 1,549,100 thousand RON, in 2020). In the field of „Waste management", investments for environmental protection of the public administration decreased by 132,500 thousand RON, in the same period, followed by the field of „Protection of the environment and climate", where they decreased by 27,804 thousand RON.

The largest investments in environmental protection by category of producers and environmental fields at national level in 2020 were registered in the field of wastewater management in public administration (Figure 1 and Table 7), representing 79.8% of total investments in this area. In fact, at national level, the share of public administration investments was the highest, 54.6% in the total investments for environmental protection, followed by the investments of non-specialized producers and those of specialized producers.

Among the investments for the environmental protection of non-specialized producers (Figure 1 and Table 6), in the field of „Protection of biodiversity and landscape", were registered 98.2% of the total, while in the „protection and sanitation of soil, groundwater and surface water", 97.8% of the field was made, and 92.5% of the total investments in this field were invested in „Protection of the environment and climate".

Among environmental areas, the highest investments for environmental protection in specialized producers (Figure 1 and Table 5) were recorded in waste management, 56.8% of the total investments for environmental protection at national level, in this field, followed by „other areas", 11.5%.

Table 7. The distribution of investments for environmental protection of public administration by environmental domains

- RON thousand current prices-

Environmental domains	2016	2017	2018	2019	2020
Protection of the surrounding air and climate	40,221	7,485	7,734	8,036	12,417
Wastewater management	941,600	756,900	1,090,900	1,549,100	1,549,100
Waste management	482,200	333,900	290,700	349,700	349,700
Protection and remediation of soil, groundwater and surface water	1,967	7,216	3,823	4,696	2,668
Biodiversity and landscape protection	0	0	100	100	100
Other environmental areas	19,212	46,798	41,643	39,768	37,415

Sources: www.insse.ro

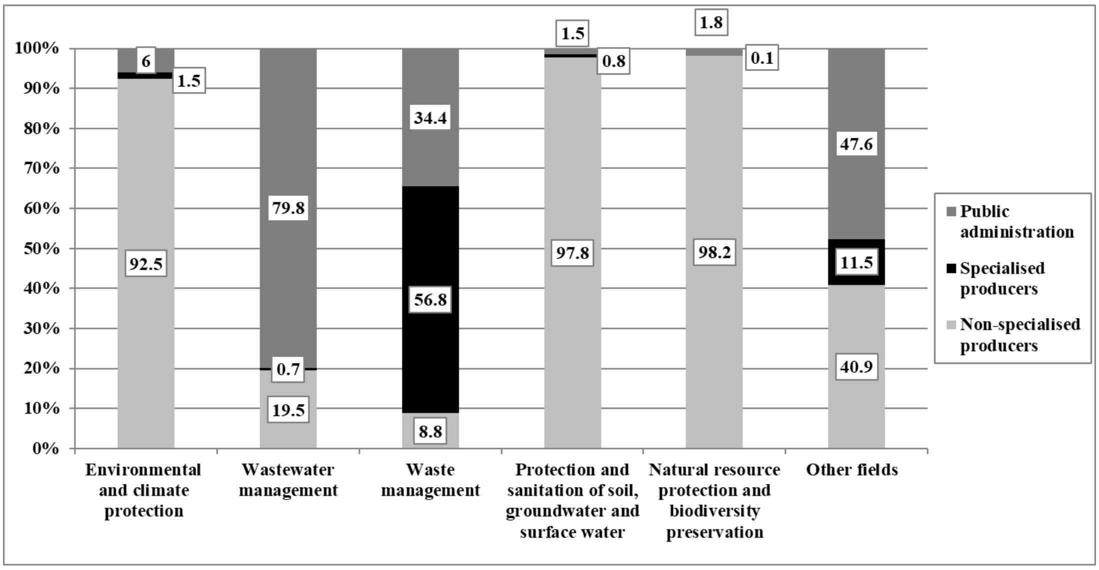

Figure 1. The distribution of investments for environmental protection by producer categories and environmental domains, in 2020.

Sources: www.insse.ro

From the analysis by development regions in 2019, the largest investments were in the Center region (24.8% of total investments), then the South-Muntenia region (16.5%) and the North-West region (14.3%). %).

The analysis by development regions of investments for environmental protection (Figure 2) indicates that the largest investments in 2020 were registered in the South-Muntenia region, 653.4 million RON, followed by the Center region, 637.5 million RON, and Southeast region, 585.6 million RON.

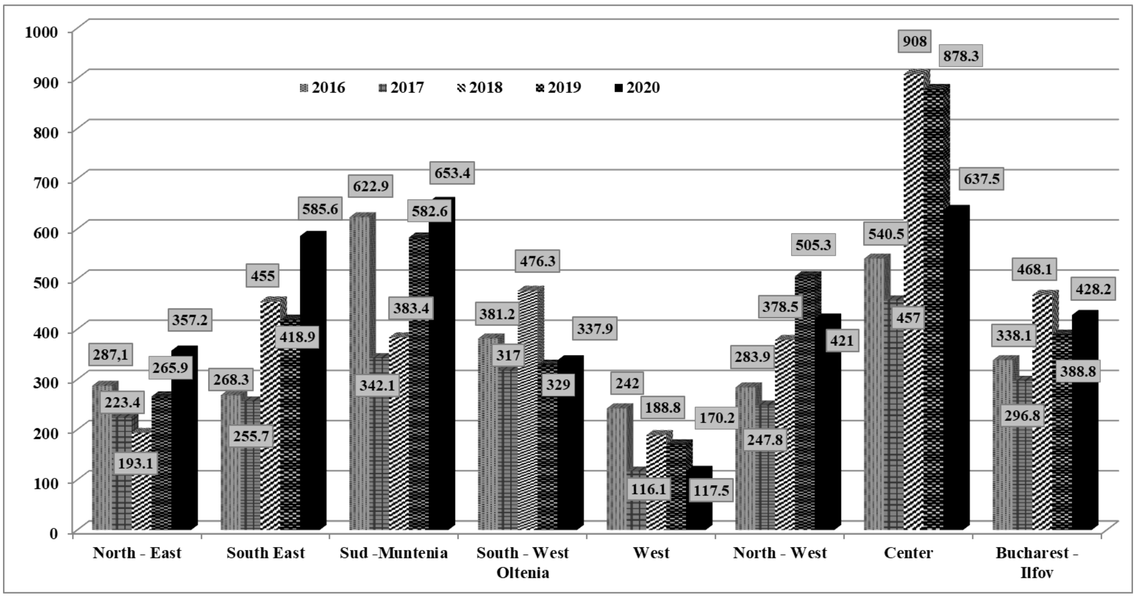

Figure 2. The investments for environmental protection, by development regions (millions of RON current prices)

Sources: www.insse.ro

The most significant investments by development regions were registered in the Center region, with an average for the entire analyzed period of approximately 684 million RON, followed by the South-Muntenia region, with an average of approximately 517 million RON and the South-East region with an average of approximately 397 million RON.

The danger of irreversible degradation of the environment implies a complete scientific understanding of the phenomena that take place and the necessary actions can no longer be postponed. As a result, it is necessary to increase productivity in scientific activity.

DISCUSSION

The environment is an essential component of human existence being the result of interference of natural elements (soil, air, water, climate and biosphere) with those created by man through his activity.

The concerns for the protection of the environment, for the protection of the natural beauties, as well as for the prevention of the abusive exploitation of the nature, are not recent in Romania.

Sustainable development is the response to the state of environmental degradation due to human activity. During economic growth, the premise of sustainable development is the cost-effective use of resources. There is a need to evaluate the efficiency of activities that favor a constant development that meets the needs of society and preserves this opportunity for future generations.

Achieving positive effects on the environment involves investing in its protection.

We found during the analysis from 2016-2020 that the investments for environmental protection were different from one year to another. Investments for the protection of the environment of non-specialized producers have registered a downward trend, against the background of the increase of the investments for the protection of the environment of the specialized producers, but also from the public administration sector.

In conclusion, it is necessary to increase investments for environmental protection while diversifying environmental protection measures. The analysis can also provide some theoretical reference for improving the efficiency of investments for environmental protection.

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STUDY REGARDING THE IMPACT OF THE PANDEMIC ON TOURIST RECEPTION STRUCTURES FROM GEOAGIU BĂI AREA, HUNEDOARA COUNTY

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ABSTRACT

Geoagiu Băi from Hunedoara county, as well as Băile Felix, Buziaş or Herculane, enjoys the advantage of being one of the oldest spa operations in the country, which dates back to the Roman colonization period. In addition to the thermal water pools that you can enjoy, the area is waiting for you to visit and admire, dozens of historical heritage sites, tourist attractions, but also protected areas and lookout points. All these have led to the development of tourism in this area and to the emergence of many accommodation units. In this study we tried to identify and analyze as many types of accommodation units as possible. The most common types of accommodation units in and around Geoagiu Băi are: hotels, hostels, tourist villas, bungalows, campgrounds, tourist and agritourism pensions. In this study we tried to highlight the importance of Geogiu Băi area within the county it belongs to.

Keywords: Geoagiu Băi, reception structures, accommodation structures, arrivals, overnights

INTRODUCTION

Geoagiu Băi, the resort town, is recognized as an ancient settlement with a rich history, born since the Roman rule in the hearth of the Germisara Baths or "Germisara Cum Thermae". From an administrative point of view, the area Geoagiu-Băi is part of the locality Geoagiu, which is located 6 km from the city of residence. Geoagiu Băi was documented in 1805. The healing qualities of the thermal waters have been known since antiquity. The ozonated air and always refreshed by the mountain breezes recommend the resort for the treatment of some diseases of the nervous system, in states of fatigue, overwork, anemia, neurosis (https://www.geoagiu.ro).

Mesothermal waters are found in the locality. The area is a nature reserve of mixed type, category IV, on the surface of 8 ha, located in the north of the balneoclimateric zone, representing a forest complex of protection value of the thermal water springs in the area (https://www.gohunedoara.com; http://turism.gov.ro/web/rapoarte/).

Figure 1. Geoagiu Băi (satellite view, map, location in Romania)
Source: https://www.google.com/maps/place/Geoagiu-Bai

According to the last national census in 2011, Geoagiu Bai had a population of 391 inhabitants (https://www.geoagiu.ro). The main objectives in the analyzed locality are the Roman Baths located near the thermal baths complex, followed by the Roman road and the Cigmău Camp.

The Romanesque chapel or Rotonda in the locality, a round church that impresses with its miniature dimensions, is considered one of the oldest stone churches in Romania. It is the only roundabout in the country still standing and visitable (Gabor et al. 2019; https://www.gohunedoara.com).

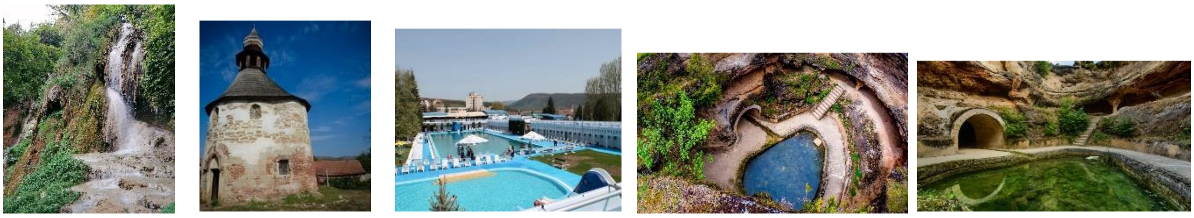

Figure 2. Tourist attractions in Geoagiu Băi
(Clocota Waterfall, Romanesque Chapel, Swimming Pool, Roman Baths)
Source: Personal archive, https://www.gohunedoara.com

Among the tourist objectives here, be sure to list the Clocota waterfall, with a height of 20 meters, and the Cave of Outlaws, from Geoagiu Băi, where a treasure would be buried (https://ro.wikipedia.org/wiki/Geoagiu-B).

Besides the attractions of the resort, you can visit and admire other important objectives nearby. At 30 km from the resort, you can visit Măgura Uroiului which has a special history. Leaving from Uroi to Deva you could stop at Simeria to visit the Dendrological Park or the Arboretum. Today, the arboretum covers an area of almost 70 hectares. The park is recognized as the oldest and most valuable collection of native and exotic trees and woody plants. The first arrangement made here was in an English style, romantic. The oldest document attesting to the existence of the park is from 1763 (Gabor et al. 2019).

Another important tourist objective that makes the analyzed area even more visited and attractive is the Corvin Castle in Hunedoara (Living Legend of Transylvania) (Csosz, 2012). The first documentary mention of the settlement of Hunedoara dates from 1278, in connection with the list of the papal tithe, Hunedoara being mentioned among the most important settlements in the archdeaconry of Hunedoara, along with Deva, Haţeg, or Sântămăria-Orlea (https://www.gohunedoara.com).

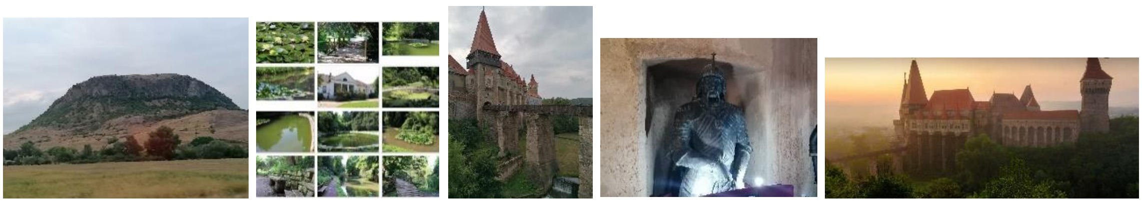

Figure 3. Tourist attractions of the analyzed area
(Măgura Uroiului, Dendrological Park, Corvin Castle)
Source: Personal archive; https://www.gohunedoara.com

MATERIALS AND METHODS

In order to achieve this study on Geoagiu Băi resort, we had the opportunity to document from various sources in the literature, we studied, analyzed, and centralized current data from national statistics, but also many information and reports provided by Geoagiu City Hall (Baltaretu, 2016; Cristea, 2018; https://insse.ro/cms/) The statistical research of the resort does not include the tourist reception structures with tourist accommodation functions with an installed accommodation capacity of fewer than 5 places (https://insse.ro/cms/). Having access to these data we were able to make a more detailed analysis of the area regarding the tourist accommodation structures, the reception structures, the number of arrivals, and overnight stays in different accommodation units. Thus, we were able to observe and compare the evolution over time of these units and how they have been affected in the last 2 years due to the pandemic situation (Csosz, 2012; https://insse.ro/cms/)

RESULTS

The ancient thermal center in the center of the town is unique in the world, say the specialists, through the way it was organized and the way the pools were organized, as well as the mobile inventory. Few people know that several gold votive plaques were found here that thanked for the miraculous healings that occurred as a result of the thermal water treatment. Due to these special tourist attractions, we were able to carry out this study to highlight the importance of the area in the practice of tourism and the development over time of the various accommodation units (Ciolac et al, 2020; Gabor et al. 2019; www.gohunedoara.com). The structure of tourist reception with tourist accommodation functions includes any construction or arrangement, which provides permanently or seasonally the accommodation service and other specific services for tourists (https://insse.ro/cms/). In Table 1 we presented the structures of tourist reception with accommodation function on different types of structures both at the level of the locality and of the county of which it is part, in the interval 1990-2021 (https://insse.ro/cms/).

The existing tourist accommodation capacity (installed) represents the number of tourist accommodation places registered in the last act of reception, homologation, classification of the tourist accommodation unit, excluding the extra beds that can be installed in case of need. The places related to the tourist reception structures with complementary tourist accommodation functions (cottages, campsites, etc.) to a basic tourist accommodation structure (hotel, motel, camping, etc.) and the use of these places are included in the basic structure (Ciolac et al, 2017; Sicoe et al, 2021).

In Table 2. during the same period of years, we presented the existing tourist accommodation capacity by types of reception structures. It can be seen how over time some structures have multiplied in number, others have stagnated, while some structures have either diminished or disappeared from the statistical evidence (Dincu et al. 2017; https://insse.ro/cms/).

Table 1. Tourist reception structures with tourist accommodation functions by types of structures (number)

Specification		1990	2000	2010	2015	2019	2020	2021
Hotels	Hunedoara	17	19	15	23	26	27	26
	Geoagiu Bai	*5*	*5*	*4*	*6*	*7*	*7*	*7*
Hostel	Hunedoara	-	-	1	2	8	9	7
	Geoagiu Bai	-	-	-	-	*1*	*1*	*1*
Motels	Hunedoara	-	-	6	6	9	10	7
	Geoagiu Bai	-	-	-	-	*1*	*1*	-
Tourist villas	Hunedoara	14	17	19	19	44	46	44
	Geoagiu Bai	*11*	*12*	*3*	-	*6*	*5*	*5*
Bungalows	Hunedoara	-	-	-	-	8	2	1
	Geoagiu Bai	-	-	-	-	*8*	*2*	*1*
Campgrounds	Hunedoara	5	-	-	1	1	2	2
	Geoagiu Bai	*1*	-	-	*1*	*1*	*1*	*1*
Tourist pensions	Hunedoara	-	-	22	25	66	81	72
	Geoagiu Bai	-	-	-	-	*1*	*2*	*1*
Agritourism pensions	Hunedoara	-	-	26	24	59	81	95
	Geoagiu Bai	-	-	-	-	*1*	-	-
TOTAL	Hunedoara	71	68	94	108	274	313	301
	Geoagiu Bai	*18*	*18*	*7*	*7*	*26*	*19*	*16*

Source: https://insse.ro/cms/

Figures 4 and 5 show the situation of the reception structures before and during the pandemic. (Cristea, 2018)

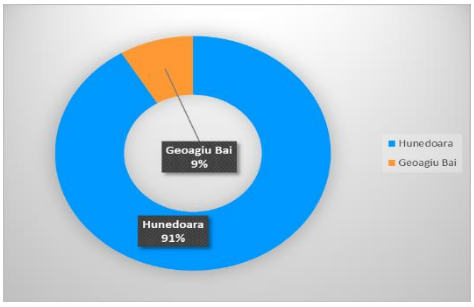

Figure 4. The situation of the tourist reception structures with accommodation function in 2019 (%, county level comparison, before the pandemic)

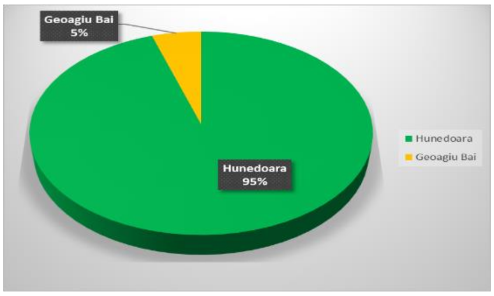

Figure 5. The situation of the tourist reception structures with accommodation function in 2021 (%, county level comparison, during the pandemic)

Source: https://insse.ro/cms/

The following figure, Figure 6, shows the evolution of the existing tourist accommodation capacity by types of reception structures in the period 1990-2021. The evolution of the existing tourist accommodation capacity can be found in Figures 7 and 8, a comparison before and during the pandemic. (https://insse.ro/cms/)

Table 2. Existing tourist accommodation capacity by types of reception structures (seats)

Specification		1990	2000	2010	2015	2019	2020	2021
Hotels	Hunedoara	2447	2088	1950	2436	2660	2369	2344
	Geoagiu Bai	847	661	737	997	1129	1073	1099
Hostel	Hunedoara	-	-	26	85	283	309	264
	Geoagiu Bai	-	-	-	-	57	57	57
Motels	Hunedoara	-	-	154	179	261	283	190
	Geoagiu Bai	-	-	-	-	38	38	-
Tourist villas	Hunedoara	842	495	618	626	1077	1065	1041
	Geoagiu Bai	642	429	281	-	128	108	95
Bungalows	Hunedoara	-	-	-	-	16	28	16
	Geoagiu Bai	-	-	-	-	16	28	16
Campgrounds	Hunedoara	174	-	-	180	180	344	254
	Geoagiu Bai	16	-	-	180	180	180	180
Tourist pensions	Hunedoara	-	-	410	591	1352	1587	1423
	Geoagiu Bai	-	-	-	-	18	38	20
Agritourism pensions	Hunedoara	-	-	339	426	881	1152	1229
	Geoagiu Bai	-	-	-	-	20	-	-
TOTAL	Hunedoara	6409	4335	3707	4942	8075	8531	7911
	Geoagiu Bai	1521	1040	1018	1177	1586	1522	1467

Source: https://insse.ro/cms/

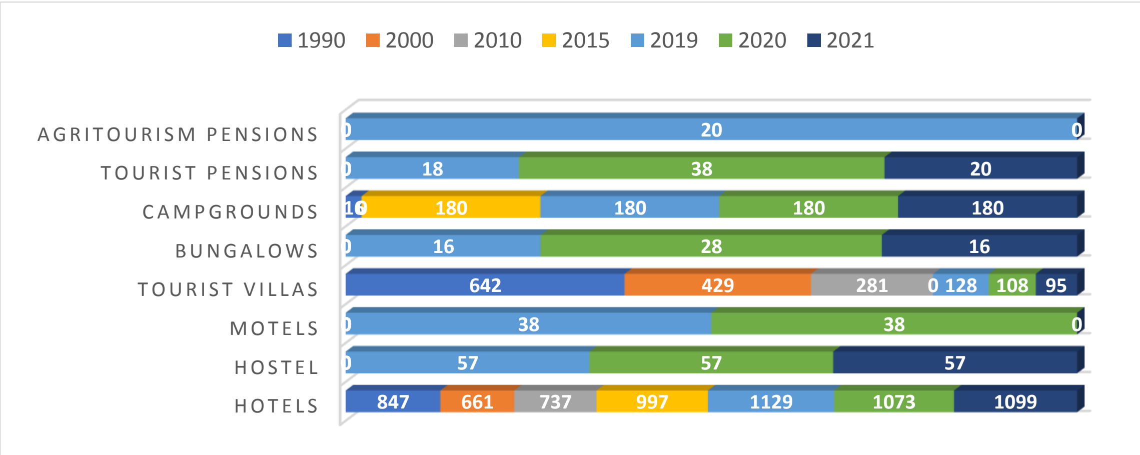

Figure 6. Evolution of the existing tourist accommodation capacity by types of reception structures (number of seats, 1990-2021)

Source: https://insse.ro/cms/

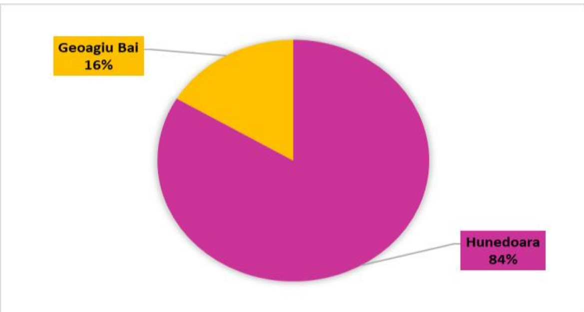

Figure 7. Total existing tourist accommodation capacity in 2019 (%, comparison at county level, before the pandemic)

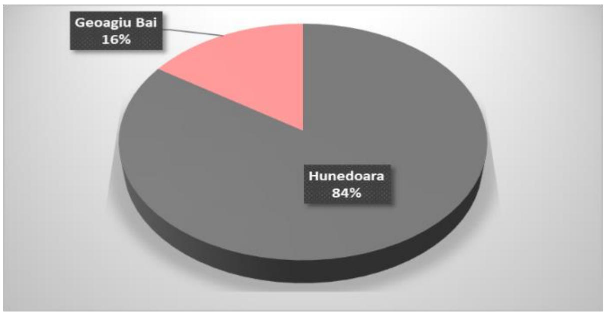

Figure 8. Total existing tourist accommodation capacity in 2021 (%, comparison at county level, during the pandemic)

The tourist accommodation capacity in operation represents the number of accommodation places made available to tourists by the tourist accommodation units, taking into account the number of days the units are open during the considered period. It is expressed in places-days. Places in rooms or units temporarily closed due to lack of tourists, for repairs, or other reasons are excluded (Dincu et al., 2016; https://insse.ro/cms/).

The situation of the tourist accommodation capacity in operation by types of reception structures is presented in Table 3. The situation is presented both at the county level and at the level of the resort analyzed in the period 2010-2020 (https://insse.ro/cms/).

Table 3. The capacity of tourist accommodation in operation by types of tourist reception structures (number of places-days)

Specification		**2010**	**2015**	**2018**	**2019**	**2020**
Hotels	Hunedoara	620657	753230	761497	764013	417013
	Geoagiu Bai	199655	284013	297217	288505	154228
Hostel	Hunedoara	8684	39030	59341	53083	23259
	Geoagiu Bai	-	-	5244	-	-
Tourist villas	Hunedoara	114997	197095	251132	251638	138543
	Geoagiu Bai	51264	-	5107	2870	186
Agritourism pensions	Hunedoara	14848	66495	148755	149288	94649
	Geoagiu Bai	-	-	-	620	-
TOTAL	Hunedoara	933333	1293654	1696125	1723402	1001781
	Geoagiu Bai	250919	284013	307568	291995	154414

Source: https://insse.ro/cms/

Figure 9. Evolution of the tourist accommodation capacity in operation by the types of reception structures in Geoagiu Bai (number of places-days, 2010-2020)

Source: https://insse.ro/cms/

Figure 9 shows the evolution of the tourist accommodation capacity in operation by types of structures in Geoagiu baths in the period 2010-2020. And Figure 10 is highlighted the total evolution of the tourist accommodation capacity in the operation of the county and the resort analyzed in the same period (https://insse.ro/cms/).

The tourist accommodation capacity in operation represents the number of accommodation places made available to tourists by the tourist accommodation units, taking into account the number of days the units are open during the considered period. It is expressed in places-days. Places in rooms or units temporarily closed due to lack of tourists, for repairs, or other reasons are excluded (Dincu, 2015; Sicoe et al., 2021).

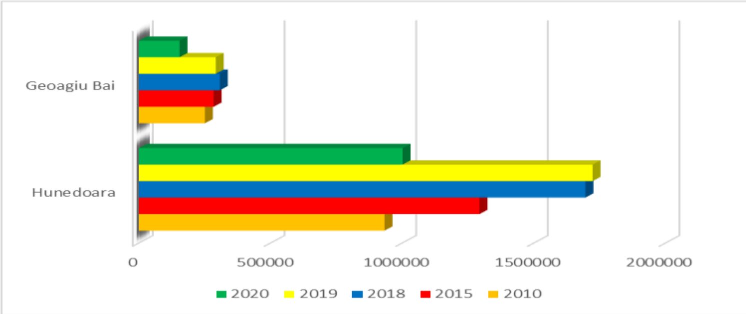

Figure 10. The total evolution of the tourist accommodation capacity in operation by the types of reception structures (comparison at county level, number of places-days, 2010-2020)

Source: https://insse.ro/cms/

Table 4. The capacity of monthly tourist accommodation in operation by types of tourist reception structures in Geoagiu Bai (places-days)

Specification	Hotels	Hostel	Tourist villas	Tourist pensions	Agritourism pensions	Total
May 2019	22475	-	-	-	-	22475
June 2019	29570	-	660	-	-	30230
July 2019	31899	-	682	-	620	33201
August 2019	31899	-	-	682	-	32581
September 2019	30870	-	660	-	-	31530
June 2020	7350	-	-	-	-	7350
July 2020	13113	-	-	-	-	13113
August 2020	22475	-	-	-	-	22475
September 2020	21750	-	-	-	-	21750
May 2021	22475	-	-	-	-	22475
June 2021	21750	-	-	620	-	21750
July 2021	31341	-	1426	620	-	33883
August 2021	27993	1767	-	-	-	30380
September 2021	21750	-	-	-	-	21750

Source: https://insse.ro/cms/

Table 4 contains an analysis of the busiest months of the resort (May-September) in 3 different years (2019-2021). It can be seen how he assessed the capacity of the monthly tourist accommodation in function by types of reception structures (https://insse.ro/cms/).

Figure 11 shows the total capacity of tourist accommodation per month depending on the tourist reception structures in Geoagiu Bai, the same months, and the same years (https://insse.ro/cms/).

The number of tourists accommodated in the tourist accommodation units includes all persons (Romanians and foreigners) who travel outside the localities where they have their permanent residence, for less than 12 months and stay at least one night in an accommodation unit. tourism in visited areas of the country; the main reason for the trip is other than to carry out a paid activity in the places visited (Dincu, 2015; https://insse.ro/cms/).

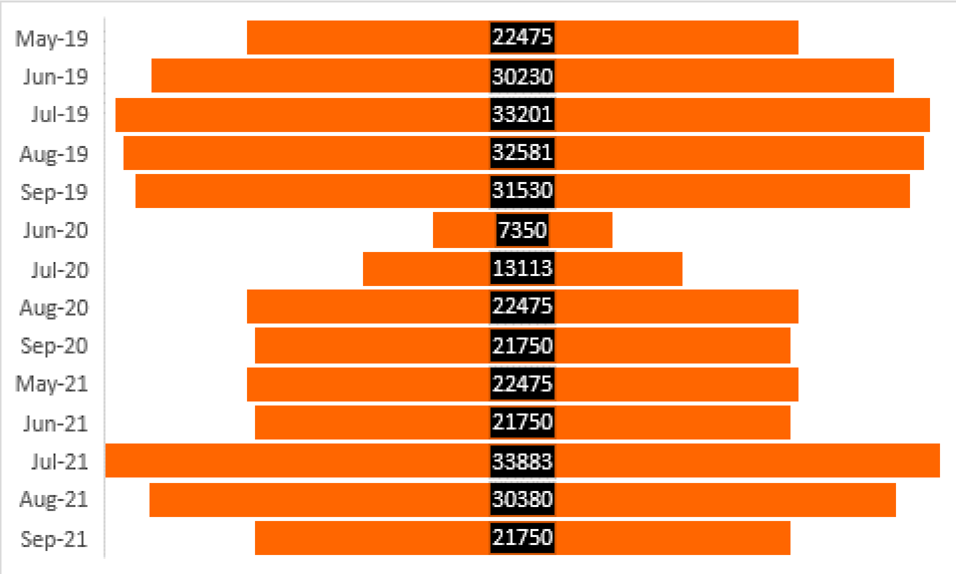

Figure 11. The total capacity of tourist accommodation per month depending on the structures of tourist reception in Geoagiu Băi (number of places-days)

Source: https://insse.ro/cms/

Table 5. Arrivals of tourists in tourist reception structures by types of structures (number of people)

Specification		2010	2015	2018	2019	2020
Hotels	Hunedoara	48618	91985	110477	111903	30898
	Geoagiu Bai	16132	32155	50714	52152	12597
Hostel	Hunedoara	663	4622	4570	3520	1510
	Geoagiu Bai	-	-	952	-	-
Tourist villas	Hunedoara	7055	22673	23543	24772	10156
	Geoagiu Bai	2373	-	1474	400	18
Agritourism pensions	Hunedoara	1417	7543	11393	11745	6961
	Geoagiu Bai	-	-	-	32	-
Total	Hunedoara	71996	151060	189526	194245	71723
	Geoagiu Bai	18505	32155	53140	52584	12615

Source: https://insse.ro/cms/

Table 5 shows the evolution over time (2010-2020) of tourist arrivals in tourist reception structures by types of structures, both in the county and in the resort. Figure 12 shows the situation of arrivals in the resort before and during the pandemic (https://insse.ro/cms/).

The tourist overnight stays in the 24-hour interval, starting with the hotel time, for which a person is registered in the tourist accommodation space and benefits from accommodation on account of the tariff-related to the occupied space, even if the actual stay is less than the mentioned interval. Overnight stays related to extra installed beds (paid by customers) are also taken into account) (Ciolac et al. 2020; https://insse.ro/cms/).

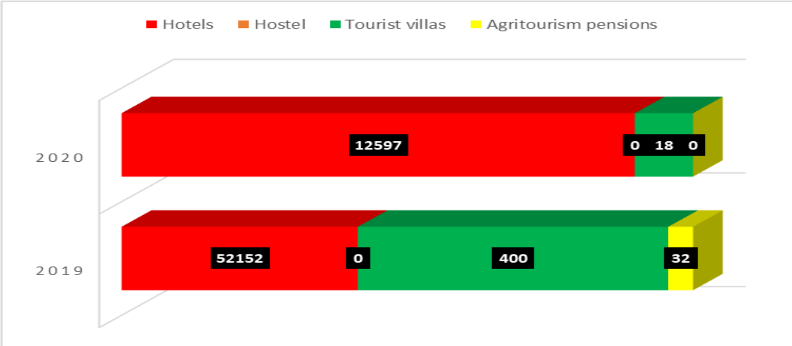

Figure 12. Evolution of tourist arrivals in the main structures of tourist reception in the period 2019-2020 (number of people)

Source: https://insse.ro/cms/

The situation of overnight stays in the tourist reception structures is presented in Table 6. The situation is presented in the interval 2010-2020, by county and the analyzed locality.

Figure 13 shows very well the situation of overnight stays in the tourist reception structures before and during the pandemic in the analyzed resort (https://insse.ro/cms/).

Table 6. Overnight stays in tourist reception structures by types of structures, number

Specification		2010	2015	2018	2019	2020
Hotels	Hunedoara	151483	240433	260719	264960	71273
	Geoagiu Bai	89109	142809	172407	172695	44783
Hostel	Hunedoara	1388	9424	8068	4832	1977
	Geoagiu Bai	-	-	2364	-	-
Tourist villas	Hunedoara	39269	38798	29841	34812	13314
	Geoagiu Bai	31404	-	3086	879	22
Agritourism pensions	Hunedoara	2506	18019	16310	19112	10386
	Geoagiu Bai	-	-	-	58	-
Total	Hunedoara	222679	343788	369286	383496	126412
	Geoagiu Bai	120513	142809	177857	173632	44805

Source: https://insse.ro/cms/

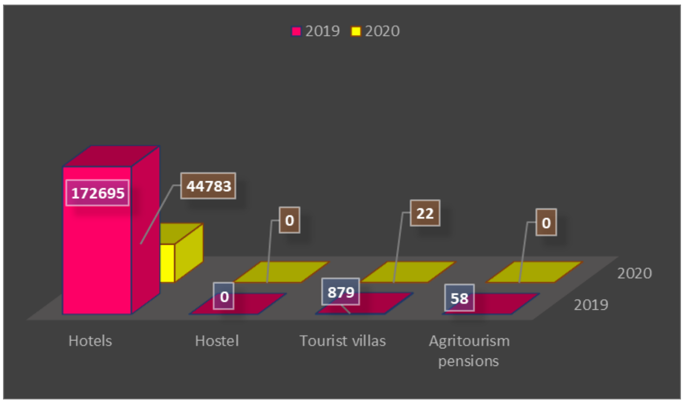

Figure 13. Evolution of overnight stays in tourist reception structures in the period 2019-2020 (number of overnight stays)

Source: https://insse.ro/cms/

DISCUSSION

Being one of the oldest resorts in the country, Geoagiu Băi is nationally recognized and visited annually by tourists, both for the beauty of the place, which looks like a huge open-air museum, and for special treatments with natural mineral waters in the center treatment. Geoagiu Băi is a suitable place where you can treat yourself and enjoy the beauty of the place. Unfortunately, the number of tourist reception structures with accommodation function in the analyzed years has not increased considerably in number. Some have diminished greatly over time or even disappeared. The existing tourist accommodation capacity by types of reception structures also did not have a very favorable evolution in the analyzed years. Regarding the number of occupied places-days, we can say that it increased in a constant time, only in 2020, during the pandemic, it decreased very much by almost half compared to normal.

The monthly accommodation capacity in the analyzed months was very good. As can be seen from the table presented in May 2020, it does not even exist in the statistics, because all the accommodation units were closed due to the pandemic. Slowly, tourists started to come starting with June 2020. From May 2021, the accommodation units started to register slight increases. The number of people arriving in the resort analyzed to stay in the main tourist reception units had an ascending trend until 2019. With the pandemic, the arrivals decreased drastically in 2020 when they were only 23%. Also, the situation of the overnight stays has changed, they have decreased a lot with the appearance of panic. Compared to previous years, in 2020, the percentage of overnight stays was only 25.4% of the total capacity of the tourist reception structures.

The historical objectives in the area of Geoagiu Bai locality are valuable but insufficiently capitalized. From Alba Iulia to Geoagiu-Bai are about 50 km, so it is in an area with many attractions to visit. Unfortunately, the state does not help this resort to develop more, to invest more in infrastructure, in the modernization of accommodation units which for a certain segment of tourists is not attractive. In conclusion, the locality Geoagiu-Bai from Hunedoara County is surprised with famous tourist objectives, but which in our opinion are insufficiently promoted and poorly arranged and signalized. Even so, Romania is worth a visit!

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http://turism.gov.ro/web/rapoarte/

CORRELATION OF THE QUALITY OF SPA TOURIST SERVICES WITH CONSUMER BEHAVIOUR

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ABSTRACT

Currently, for an increasing number of companies, the competition is no longer manifested locally, but globally. As long as national markets are open, there is an influx of foreign products, cheaper, better. There is the problem of making products competitive with those on the world market. The company leaders consider that the main objective is to improve the quality of products and services, thus noting a close relationship between the quality of services and products, customer satisfaction and company profitability. A high level of quality, leads to a high level of customer satisfaction, sometimes involving high prices. Satisfaction is the result felt by a buyer following his relationship with a company whose performance has risen to expectations.

Keywords: quality, services, consumers, competition, spa.

INTRODUCTION

Although most scholars consider tourism a phenomenon specific to the contemporary period, it emerged at the end of the nineteenth century. The rapid development of this field was due to the achievements offered by the contemporary technical-scientific revolution which consisted in the development and modernization of means of transport, accommodation and food units.

Romania is among the countries with the largest mineral and thermal water resources in Europe that have miraculous therapeutic effects, some of them being in Slănic Prahova resort. Thus, the main attraction is the salt lakes, but also the Slănic mine.

Through its social and economic effects, spa tourism has become one of the most important segments of international tourism, concentrating important material and human resources, with deepening impact of science and technology, which highlight the material spa factors succeeding in providing tourist services and medical of a complex bill and of a high quality level (Chis et al., 2014).

The spa tourist offer is completed by a natural geographical setting, most of the times of a special beauty, considering that most of the springs and mineral lakes are located in the hilly and mountainous areas, where tectonic accidents bring to light one of the riches Earth.

Since the location of a spa resort cannot be chosen a priori, as they are conditioned by the presence of the mineral source, the man intervened by his activity to improve the environmental environment. Parks and gardens have been set up, which can reach hundreds of hectares (Vichy-France), resulting in so-called "spa parks", forests have been planted that create a sedative, recreational and relaxing climate where they did not exist, radically changing the original appearance.

The environmental framework - natural and built, through all its components must respond to the need to represent an alternative program for those who come to the spa.(Probeani et al., 2016).

Romania, due to its geographical location and the complex geological structure of the earth's crust, has a great wealth of natural cleaning factors - mineral waters, skunks, muds, therapeutic lakes - generously spread over almost the entire country, in different climatic zones (Martin et al., 2014).

On the territory of our country there are almost all known types of water – oligomineral, alkaline, alkaline-earthy, chlorinated-sodium, iodinated, sulfated, ferruginous, arsenical, sulfurous, carbonated, radioactive, etc. - with a very wide variety in terms of their chemical composition, degree of mineralization and temperature.

The skunks (natural emissions of therapeutic gases) contain carbon dioxide or hydrogen sulfide, and the therapeutic sludge is sapropelic, peat and mineral.

Our country also has various types of climate, in relation to geographical units and altitude (coastal climate, plains, hills and hills, medium and high mountains).

It is known that a number of natural healing factors were used for treatment almost two millennia ago, with material evidence that the Romans used the mineral waters of Baile Herculane for therapeutic purposes.

Over time, the discovery of mineral waters and muds created the premises for the emergence of bathing establishments, at first more rudimentary, which since the eighteenth and nineteenth centuries have gradually developed (Onose et al, 2020).

After the Second World War, the material base of the resorts was modernized, expanding and diversifying at a dizzying pace, especially in the last decade. Today, our country has over 160 resorts and localities with natural healing factors. In many of them, intended for the treatment with natural factors, modern units have been built such as treatment hotels and sanatorium complexes, in which accommodation, meals and treatment services are offered in the same building (eg Băile Felix, Herculane, Sovata, Băile Tușnad, Covasna, Căciulata, Amara, Sângeroz-Băi, Mangalia, Slănic etc.)

Current and future investments continue to focus on the development of these types of constructions, thus allowing the treatment to be administered with the same effectiveness throughout the year, not only in the hot season. In the modern treatment bases built in resorts, optimal conditions for the complex use of natural healing factors have been created, based on the results obtained in medical scientific research. In parallel with the natural healing factors, the spas also have a wide range of therapeutic procedures that use artificial physical factors grouped in the departments of physiotherapy, mechanotherapy, pneumotherapy and others, equipped with modern facilities and equipment.

Spa tourism is addressed not only to those with medical problems, but also to those who want to relax, to regain their vitality and a good physical, mental and spiritual condition (Runceanu-Albu, 2021).

Due to this fact in recent decades, through its important social and economic effects, spa tourism has become a major segment of the international tourism market, which focuses on important material and human resources, with increasing involvement of science and technology, the provision of tourist and medical services of a complex bill and of a high quality level, called to satisfy the vital requirements of the modern man, determined by the evolution of the living conditions and the health condition of the population (Munteanu, 2020).

Through its important social and economic effects, spa tourism has become a major segment of the international tourism market, an area that concentrates important material and human resources, with increasing involvement of science and technology, the provision of tourism and medical services complex and of a high quality level, called to satisfy the vital requirements of the modern man, determined by the evolution of the living conditions and the health condition of the population (Onose et al, 2020).

Romania is one of the European countries with a remarkable spa fund:

A quarter of the thermal and mineral waters on the continent are found in our country. This value is accentuated by the complexity of natural factors, namely the finding in the same resort of the main environmental factors, along with a wide range of healing minerals, as well as the existence in Romania of all types of spa minerals that can be used throughout range of spa treatment profiles. Locals know this data, empirically, from ancient times.

Thermal and mineral bath installations have been discovered since the time of the Roman conquests. The remains of almost 2000 years are found in many of today's resorts. Therme Herculi, today Băile Herculane, was famous in the Roman Empire for the healing qualities of its mineral waters.

Many of today's spas continue an old tradition, and in the 18th and 19th centuries they gained European recognition, becoming favorite places for treatment and leisure.

In 1924, the Institute of Balneology was established, the second in Europe, and the treatment of diseases using natural factors became the main concern of researchers and doctors. In Romania, spa tourism has developed continuously, had an extensive character in the ‘70s and 80's, and at present it is mainly oriented towards high quality spa recovery or prophylaxis services.

Spa tourism is a major component of the Romanian tourist offer and is addressed not only to those with medical problems, but also to those who want to relax, regain their vitality and regain a good physical, mental and spiritual condition (Chis et al., 2014).

Quality strategy is a winning strategy. Through it, everyone gains: consumers, producers, managers, in a word, the whole society. A well-rendered service is a profitable strategy for the company and also offers greater satisfaction to consumers. A quality service results in attracting new customers, an increased turnover with the current ones and the loss of as few customers as possible (Constantinescu et al., 2017). Quality is the main element that creates loyal consumers, consumers are satisfied that they have chosen the company after experiencing their services, consumers who will use the company's services in the future and will recommend it to others (Martin, 2014).

Quality, in the service industry, is what differentiates one company from another, the quality of service being the most important competitive element (Martin, 2014; Dinu, 2011).

A high quality service is a profitable strategy because it ensures greater price stability in close competition and because it prevents the wrong provision of many services, the cost of which would be higher. If the service is provided at a higher quality level, the profit will be commensurate. The good quality service is also a satisfaction because on its basis a culture is built in the restive company (Martin, 2014; Dogaru, 2016).

The quality of the services is closely linked to all stages of the service, from the initial order to its sale and subsequent period. Given the intangibility of services, these characteristics can be called "permanent quality delivery" and they are increasingly a central element for service management and therefore a key factor in marketing strategy (Pascu, 2016, Martin, 2014, Martin et al., 2014).

MATERIALS AND METHODS

In the elaboration of the paper we set out to highlight the development potential of tourism, from a spa point of view, within the Slănic Prahova resort.

Our investigation includes two successive researches: a quantitative research of exploratory type that has as primary purpose the highlighting of the qualitative aspects of the investigated moment and a qualitative research of descriptive type carried out in the form of a selective survey.

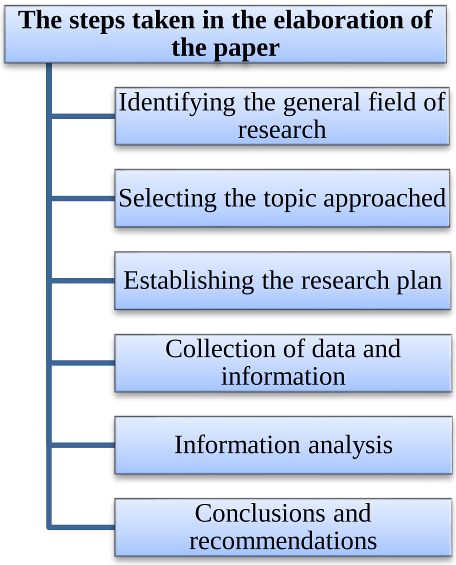

Figure 1. The steps taken in the elaboration of the paper

Source: own construction

Of all the approaches in the literature, representing all variations on the same topic, the method of the six steps was chosen to improve the quality of spa services. This method is a structured approach to problem solving and process improvement. Solving the problems in Slănic Prahova resort requires 6 concrete steps, where the case requires a careful approach representing a barrier between what is happening and what should happen. The 6-step diagram involves the following: 1. identifying and selecting the problem; 2. problem analysis; 3. generating possible solutions; 4. selection and planning of solutions; 5. implementation of solutions; 6. evaluation of solutions.

In order to find out the customer dissatisfaction, a survey was conducted based on the application of a questionnaire, this method of finding out the opinions of customers about the services provided was a simple, easy method and due to its realization, the survey was the starting point to improve service quality. The survey was conducted in July-August 2021 and applied to a number of 320 people, from various social backgrounds, chosen at random.

RESULTS

In theory and in specialized practice there are several ways of structuring the components of the technical-material base of tourism.

The most important component of the specific technical-material base is the network of accommodation units, it responds to one of the fundamental needs of tourism - rest. Moreover, the dimensions, structure and spatial distribution of the means of accommodation determine the characteristics of all other component equipment of the technical-material base of tourism.

The technical-material base of Slănic Prahova resort consists of the technical-material base specifically for tourism and infrastructure. Tourist equipment is represented by the network of accommodation units, part of the network of food units, means of transport in the structure of tourism, leisure facilities and those specific to spa treatment, tourist villages and holiday villages.

The analysis of the technical-material base involves the presentation in structure and dynamics, in tabular form, of the existing accommodation units in Slănic Prahova, their distribution in the territory, by types of units and comfort categories, as well as the number of existing rooms in the tourist reception structures.

The tourist reception units in Slănic Prahova resort are characterized by diversity, complex facilities, location in a special natural setting and relatively uniform distribution, managing to satisfy the needs and preferences of the arriving tourists.

Table 1. Tourist accommodation capacity in the period 2017-2020 (places)

Types of units	**2017**	**2018**	**2019**	**2020**
Hotels	240	240	240	270
Treatment hotels	46	46	46	46
Pensions	20	20	20	20
Villas	45	40	40	40
TOTAL	**351**	**346**	**346**	**376**

Source: data obtained from the resort

Regarding the accommodation capacity of the existing units in the resort, in 2020, there is an increase in the number of hotel accommodation from 240, in the period 2017-2019, to 270 places. A decrease in the number of places is observed in the case of villas, their accommodation capacity decreasing from 45 to 40 places, in the period 2018-2020 compared to 2017. This decrease is not caused by the reduction of the number of villas, but by decommissioning of some rooms, which no longer met the operating requirements.

It can be seen that accommodation capacity has constantly evolved. With the increase in the number of rooms, the accommodation capacity has also increased. The accommodation capacity from 2020 compared to 2017 registered an increase of 7.12%. Also in 2019 there was a decrease in the number of units by 1.42%

Table 2. Number of tourists arriving in Slănic Prahova resort during 2017-2020

	2017	**2018**	**2019**	**2020**
Tourists resident in Romania	5727	5733	5553	5956
Tourists not resident in Romania	6	8	7	13

Source: data obtained from the resort

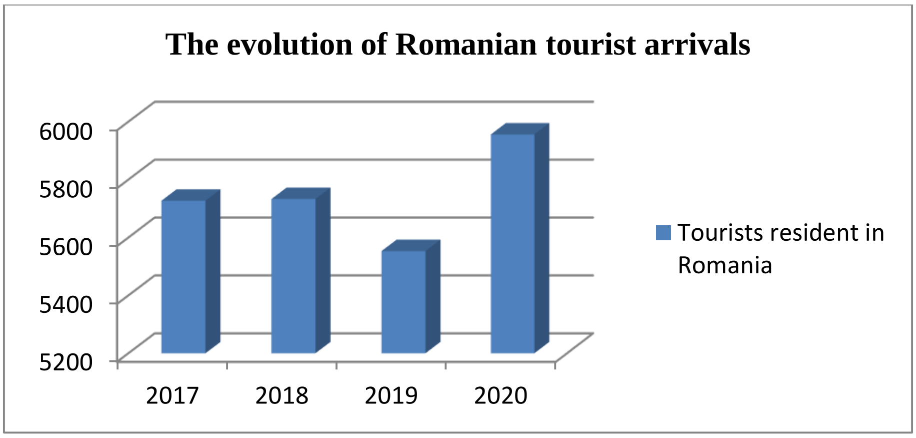

Figure 2. The evolution of Romanian tourist arrivals
Source: processing according to the data obtained in the resort

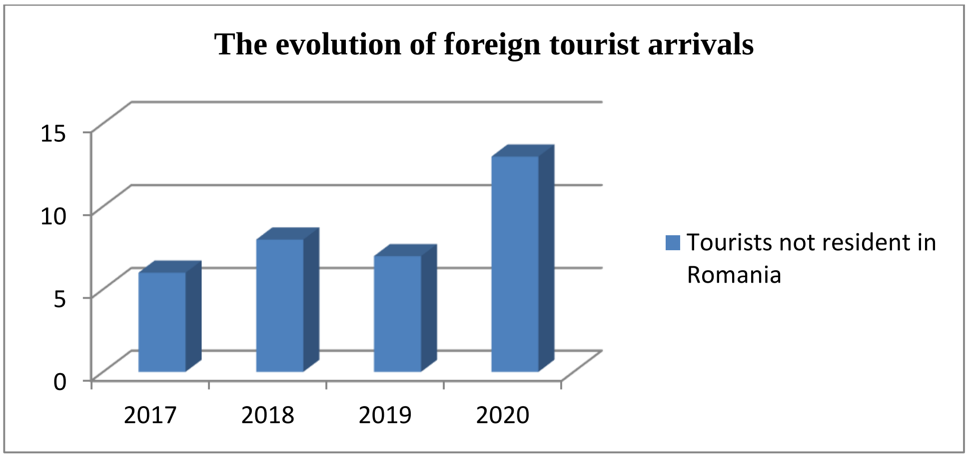

Figure 3. The evolution of foreign tourist arrivals
Source: processing according to the data obtained in the resort

Comparing the number of Romanian tourists with that of foreigners arriving in Slănic Prahova, it is observed that the resort enjoyed during the analyzed period, an increase in the number of tourists, except for 2019, when there is a decrease of 43.75%. Regarding foreign tourists, it can be seen from the graph that their number is constantly evolving, except for the year 2020 when there is an increase of 143.75%. The ascending evolution registered during the four years means the fact that Slănic Prahova resort is more and more attractive, offering quality services at affordable prices. It is endowed with valuable and efficient natural resources and equipped with equipment (treatment bases) that covers a wide range of needs and preferences.

Quality is the decisive factor in tourism services, especially in terms of the service process, staff characteristics and the maintenance of economic activity on the market. In order to find out the quality of the spa services in the resort regarding the preferences and satisfaction of the customers, we contacted the customers based on a questionnaire.

Its purpose is to have an analysis on the quality level of products and services offered by the spa resort Slănic Prahova, detecting consumer issues, as appreciated by Feigenbaum: "Quality is what your customer says it is, not what you say you. In order to know the level of quality you offer, ask your customer." Based on a set of questions for loyal and potential customers, the aim will be to determine the errors and eliminate the causes in relation to quality and consumers. Aspects of the appreciation of the services offered by Slănic Prahova resort are shown in the figures below.

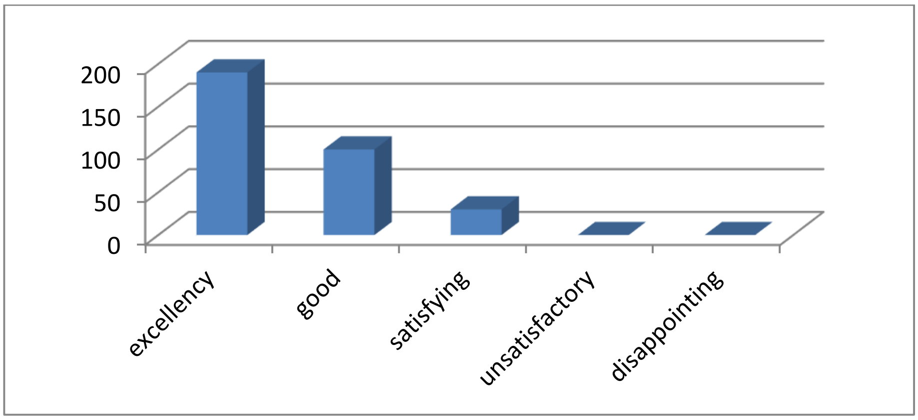

Figure 4. The quality and professionalism of the spa services expressed as a percentage
Source: own processing according to the data of the questionnaire

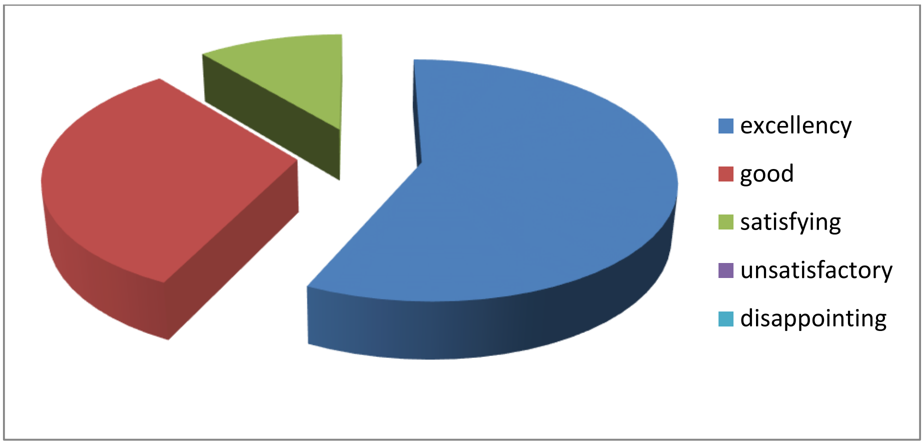

Figure 5. The quality and professionalism of the spa services expressed as a percentage
Source: own processing according to the data of the questionnaire

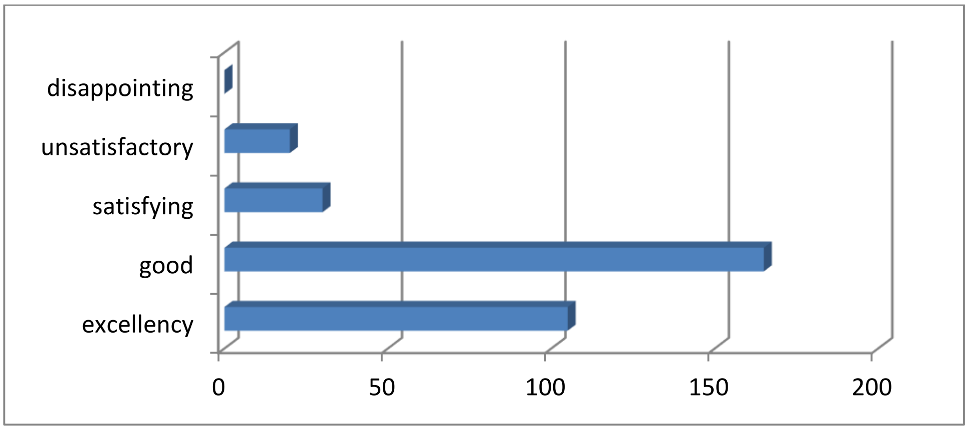

Figure 6. Availability of spa and treatment services
Source: own processing according to the data of the questionnaire

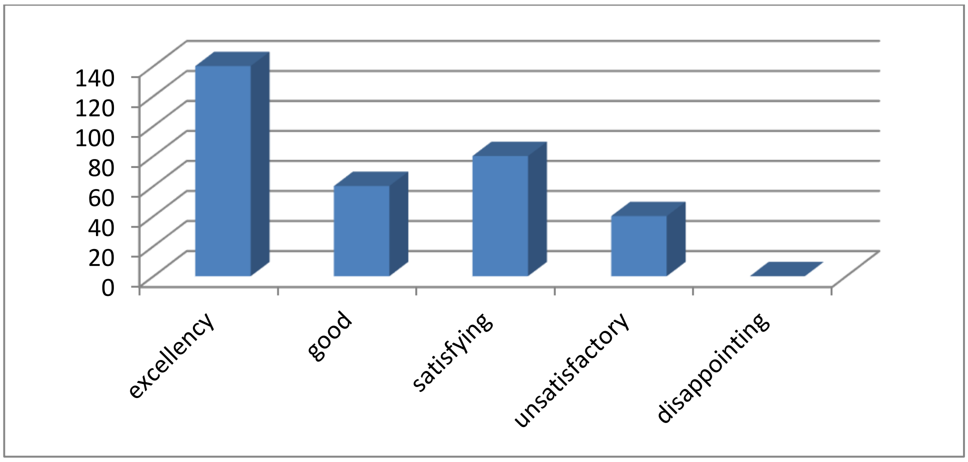

Figure 7. Diversity of services
Source: own processing according to the data of the questionnaire

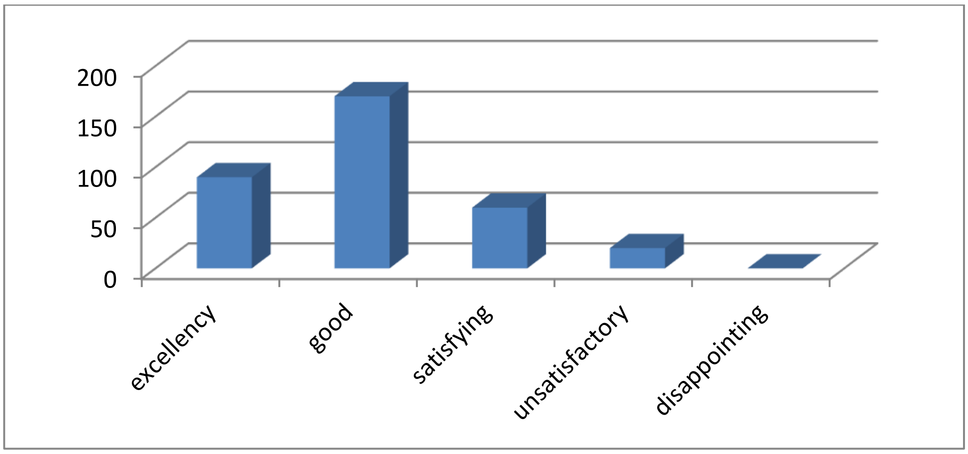

Figure 8. Availability of services
Source: own processing according to the data of the questionnaire

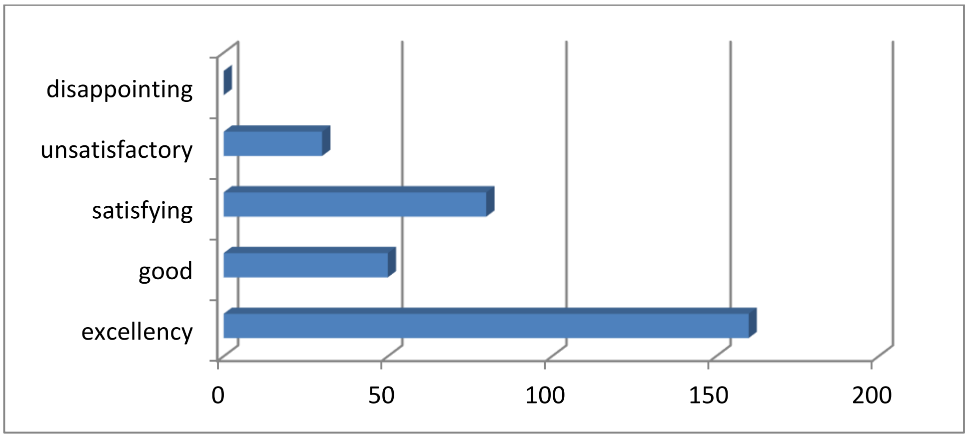

Figure 9. Prompt performance of services
Source: own processing according to the data of the questionnaire

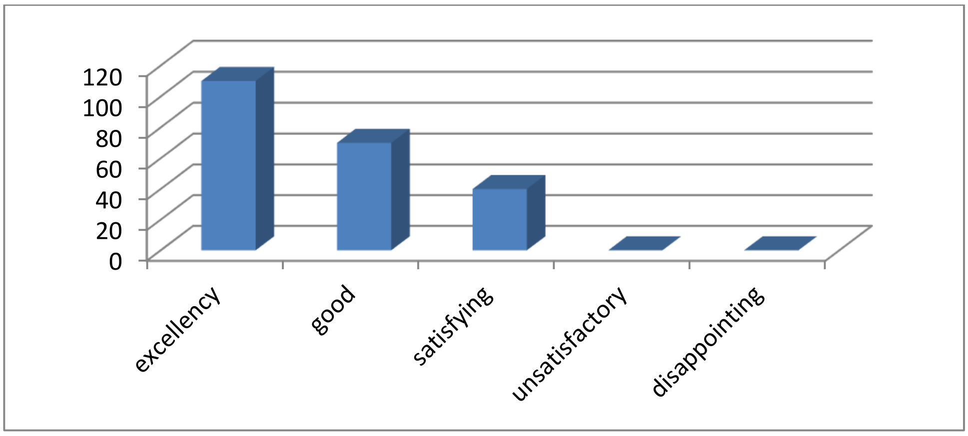

Figure 10. Quality and variety of services
Source: own processing according to the data of the questionnaire

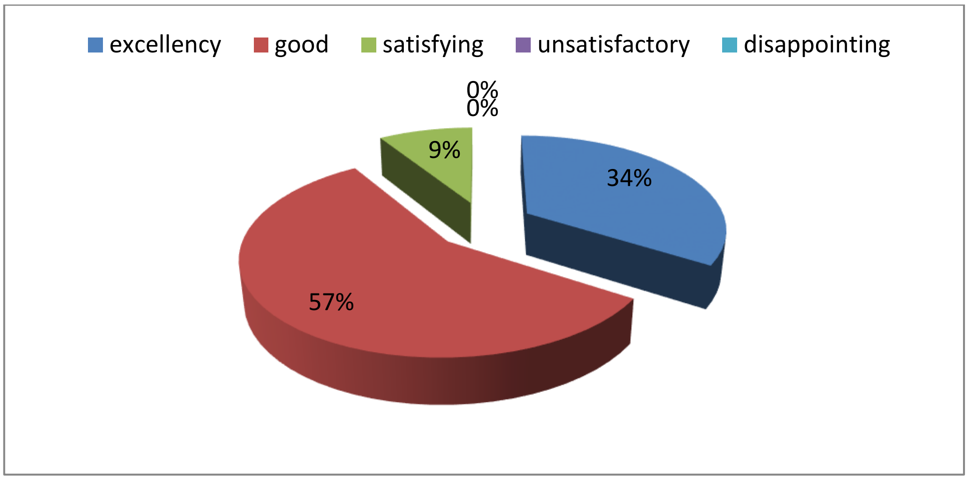

Figure 11. Quality/price ratio

Source: own processing according to the data of the questionnaire

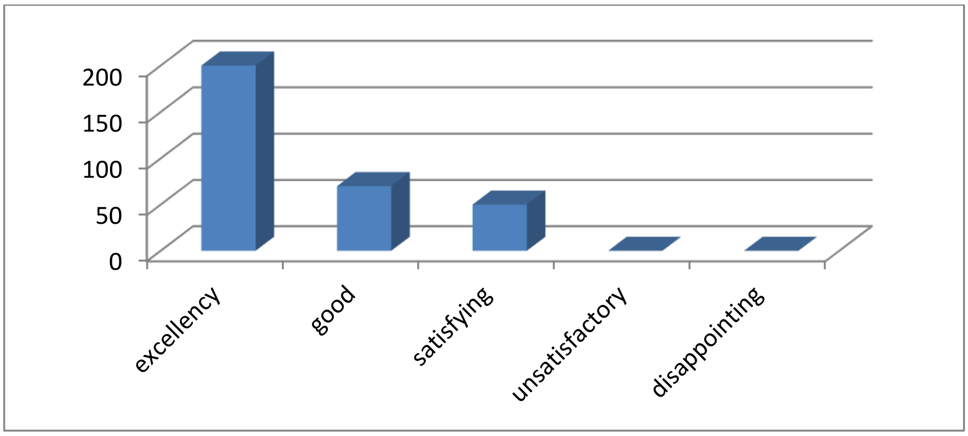

Figure 12. Friendliness of staff

Source: own processing according to the data of the questionnaire

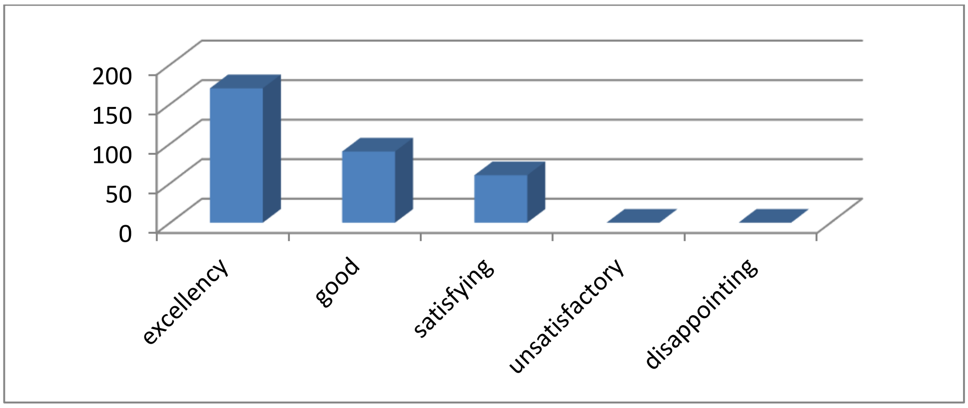

Figure 13. Professional competency

Source: own processing according to the data of the questionnaire

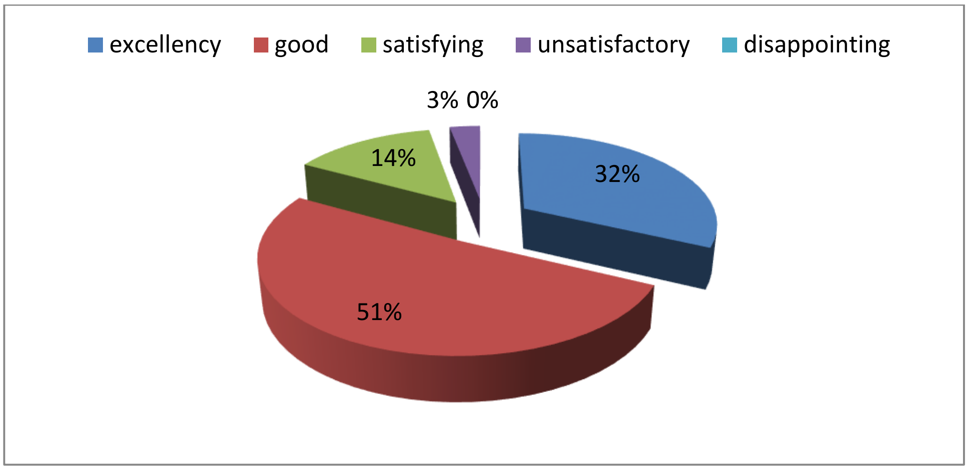

Figure 14. Promptness of staff in meeting customer needs
Source: own processing according to the data of the questionnaire

The aspects of the services in the resort, rendered by the customers, are the following:

- Promptness of services 80.6%.
- Professional competence 77.4%,
- Staff friendliness 80.6%,
- Quality/price ratio 90.3%,
- Quality and variety of services 87.1%,
- Promptness of meeting needs 74.2%,
- Availability of services 93.5%,
- Quality and professionalism of services 90.3%.

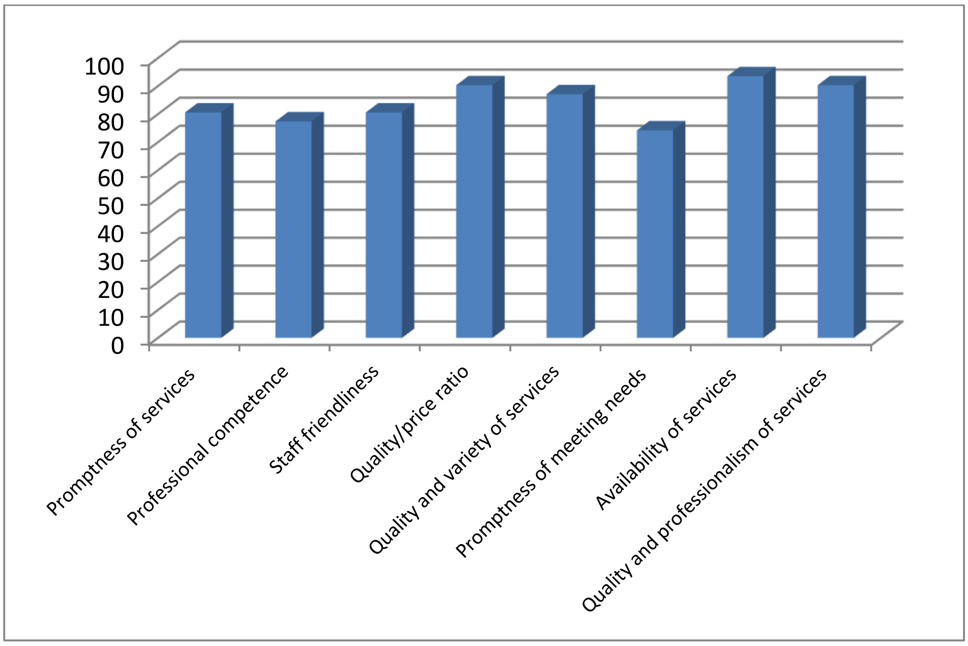

Figure 14. Histogram of experiences
Source: own processing according to the data of the questionnaire

The percentage result is the calculation of good and very good values estimated by customers. Based on the resulting data, values between 80% and 100% meet customer needs, but need to work on some important issues:

- The promptness of honoring the services must be done in a short time.
- Professional competence will be enhanced based on careful training of staff. In this sense, the staff will be motivated and bonuses will be allocated to each test passed.
- The kindness and promptness of the staff is good, but we are not satisfied with that.

Kindness and respect will always come first and customers will understand if they feel respected. With regard to the quality of services and products, consumers have the legal right to be fully, correctly and accurately informed of the essential characteristics of each product and service, so that the decision they make in this regard is best suited to their needs, and to be educated as consumers.

DISCUSSION

In order to become an increasingly sought-after tourist destination, Slănic Prahova needs a much more developed technical-material base, especially from the point of view of leisure, which, in recent years, has become a very important motivation in practicing tourism. The resort is known for its sanatorium arranged inside the salt mine where tourists can treat various respiratory ailments, but also relax. Due to the natural potential, certain tourist packages can be made in order to meet the increasingly diverse needs of tourists. The main measures that should be applied for the realization of a tourist activity developed in Slănic Prahova are: the creation of programs and funds for the co-financing of regional development projects, the correlation of national programs with those of local and regional interest, the extension of communications in areas of tourist interest, efficient and modern transport, promoting the zonal tourist potential by participating in tourism fairs, by conducting advertising campaigns, preparing brochures with information about the tourist potential of the resort and with suggestive images in this regard, media coverage of pensions and the existing tourist complex.

The transport infrastructure in Slănic Prahova is not sufficiently developed and requires significant investments to be at the level of European standards. Investments should be directed to roads, and access roads to the resort. Integrated rehabilitation projects are needed for the salt museum, but also for the salt mine.

- Realization of access roads and tourist markings in the neighboring and specific areas of the region
- Restoration of tourist infrastructure (parking spaces)
- Rehabilitation, modernization and expansion of accommodation infrastructures with appropriate utilities.
- Increasing the quality of services by creating and rehabilitating recreational facilities
- Stimulating the introduction of all inclusive services.
- Imposing a ceiling on the development of tourist structures and equipment
- Development and promotion of sustainable tourism, based on ecological principles, combating pollution in general and especially in areas with high tourist traffic.
- Increasing the participation of the population in tourism activities, as a means of physical and mental recovery, rest and recreation, recovery of health, enrichment of knowledge and development of relationships between people and tourists.
- Attracting and stimulating the local community in the development of tourism in order to increase their income and the development of the resort, increase the quality of life of the local population

- Reformulation of the spa product from thermalism to health tourism. The costs involved in this process will be considerable, but this strategy will attract a wider international market and will also target high-income domestic tourists.
- Promotion of natural resources (sludge, mineral waters, etc.) both for cures and for preventive and beauty treatments
- Creating information centers, maps and plans;
- Introduction of high quality facilities and fitness and beauty services, modernization of treatment centers and endowment with high-level equipment, construction of saunas, indoor and outdoor pools and resort pools
- Diversification of menus and development of high quality cafes and restaurants.

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POSSIBILITIES FOR OPTIMIZING THE IRRIGATION SYSTEM IN ROMANIA

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ABSTRACT

One of the natural limiting factors of the vegetal agricultural production in Romania is represented by the water, which, together with the permanent lack of capital, determined the obtaining for three decades (1990-2020), of an average production of only 40%, compared to EU-15 average. Thus, in this paper, the authors propose, given the inadequate performance of agriculture, to find solutions to revitalize the irrigation system, taking into account the rich hydrographic system of Romania.

Keywords: climate change, production level, optimization, irrigation

INTRODUCTION

The non-performance of the annual agricultural production in Romania is generated, first of all, by the dependence still too high on the annual weather conditions, due to the fact that irrigation systems were used incompletely before the year of 1990, and after this year they are, in large part, inoperative due to physical degradation, poor equipping of farms with irrigation facilities, all of these led to high costs for water irrigation (Otiman 2019). At the same time, by using outdated agricultural technologies, with low consumption of inputs that support performance (fertilizers, plant protection substances) and some technical equipment exceeded in terms of energy consumption and productivity, had generated economic non-performance and of permanent production.

Romania numbers among the category of European countries with modest water resources (11th place for total resources and 21st place for those formed on its territory) (Nicolescu et al. 2017). Romania's water resources have a feature given by the fact that a rate of 97.8% of national hydrographic network is collected from the Danube River, with a length of 1,075 km on the country’s territory. The hydrological (natural) resource, expressed by the multiannual average stock of flowing waters, is 128.1 billion cubic meters per year, of which 40.4 billion from the inland rivers, and 87.7 billion from the part that Romania belongs from the multiannual average stock of the Danube. The volume of groundwater is estimated at 9.62 billion m^3/year. The specialists estimate, as usable sources of water, the following quantities: 10.8 billion m^3/year from the landscaped inland waters, 5 million m^3/year from the Danube River in landscaped regime and 3 billion m^3/year from the groundwaters (Davidescu, 2010).

Romania poses a considerable risk to climate change, the effects of which being clearly reflected by changes in temperature and precipitations (Ministry of Agriculture and Rural Development, 2019). The extreme and severe pedological drought in the southern and eastern areas of Romania, in conjunction with the high-water consumption during July-August, lead to a ground water reserve often located below the point of wilting on large agricultural areas. In these areas, the complex agricultural drought is a climatic phenomenon of hazard that induces the worst consequences that have ever been recorded in agriculture (Otiman 2019).

Rainfall with a multiannual average of 580 mm (Băneș 2016), across the country also shows notable differences between regions (between 1,200-1,400 mm per year in high mountain areas and 400-500 mm in the main agricultural areas of the Romanian Plain), as well as over time, periods of dryness and severe drought alternating, sometimes even during the same year, with periods of excessive humidity causing significant damage (flooding, landslides).

Irrigated land reduces the dependence of crops on the volume of rainfall and minimizes the risk of droughts affecting agricultural production. At the same time, irrigation can increase the productivity of cultivated agricultural land, allowing the expansion of cultivated areas in some semi-arid areas (Romanian Government, 2018).

MATERIALS AND METHODS

The purpose of this work is to analyze the situation of irrigation system in Romania and to offer solutions for the revival of irrigation system, considering the rich hydrographic system of Romania.

The materials that formed the basis of this study were articles in the field, reports and statistics of Agriculture and Rural Development Ministry, the National Institute of Statistics as well as specialized web sources.

The research methods used were fundamental (academic) research and applied research, oriented towards the analysis of the collected data, thus contributing to the formulation of relevant conclusions on the irrigation system in Romania.

RESULTS

Even though at the end of 1989, Romania had designed for irrigation in large systems the area of 3.1 million ha (21% of the agricultural area), of which 2.9 million ha arable (30% of the arable area of the country), being, from this point of view, on the 2nd place in Europe, the effects of irrigation have not been felt strongly, technically and economically, neither before 1989 nor at present at the level of the average harvests at the surface unit. In reality, the huge financial and material effort during the communist period did not materialize in production due to the partial use of the surface arranged for irrigation, and the extensive nature of the agriculture practiced in most of these systems and of the low technical and economic efficiency to use irrigated water.

The low technical performances of the irrigation systems have as causes: the outdated technology, materialized in the low density of the network, the high water losses by infiltration into the open channels no-waterproofed and evaporation, the extremely expensive technical solution of ducting water intake (by pumping from the Danube, in two or more steps, requiring a high energy consumption for the transport of water from source to plant, compared to other countries, where the gravitational system of bringing through the main channels is used, the energy being used only for the transfer of water from the channels (pipes) from the inland distribution of the agricultural holdings up to the plant.

From the statistical data of the period 1962–1990, it appears that in no year for reasons of "economy" for electricity caused by the permanent energy poverty, an area more than 1.5 million conventional ha wasn’t irrigated. But even on this surface, the technology of crop irrigation has been deficient, both in terms of the norm of irrigation and watering, and in terms of the intervals between waterings. It is known that improper irrigation has much lower technical and economic effects compared to the ratio of the optimal norm and the average allocated norm.

After 1990, the irrigation systems were physically damaged, by clogging and destroying the watertightness, even now precarious, of the channels, as well as by stealing the technical equipment from the pumping stations, of distribution pipes and the watering machines in the field. The effects of this state of fact were felt especially in the years 1992, 2000, 2007 and 2011, extremely dry, years in which Romania, in our assessment, lost about 6 million tons /year of cereals, soybeans and sunflower due to the fact that the minimum area of one million hectares was not irrigated.

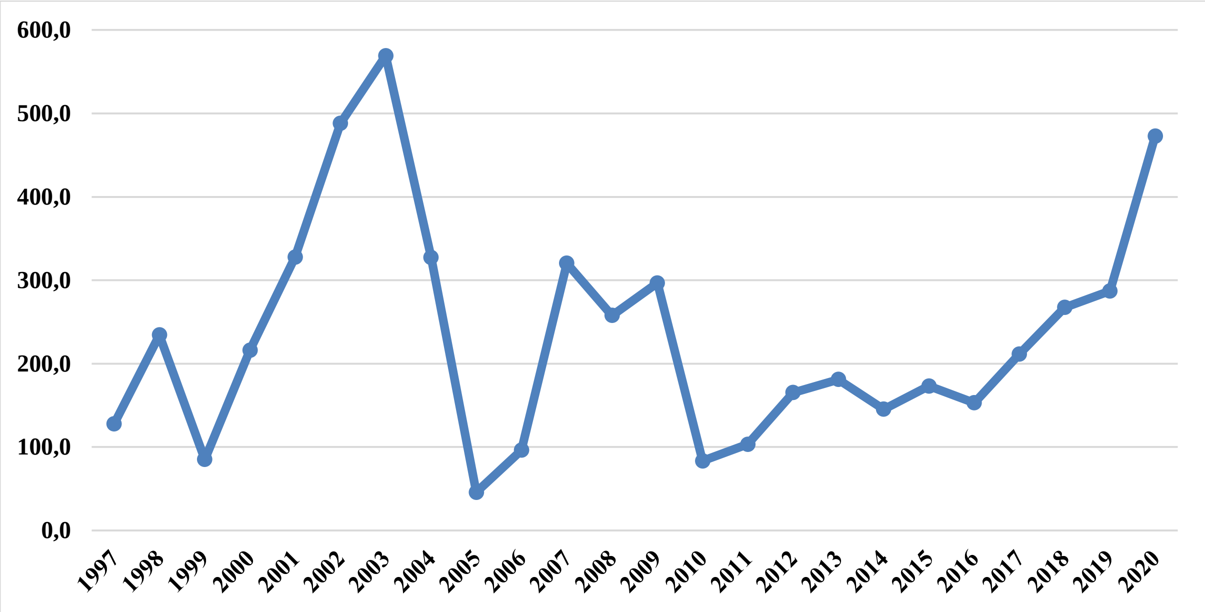

Figure 1. Irrigated arable land in Romania (thousand ha), - historical data

Along with the degradation and destruction of irrigation systems, through the incorrect, arbitrary application of Land Fund's Law and those related to it (the law on agricultural companies and associations, the Law on privatization of agricultural commercial societies, etc.), agriculture has entered into a deep process of restructuring, both of the property and of holdings, with important implications on the cultivation technologies, including the irrigation of the crops.

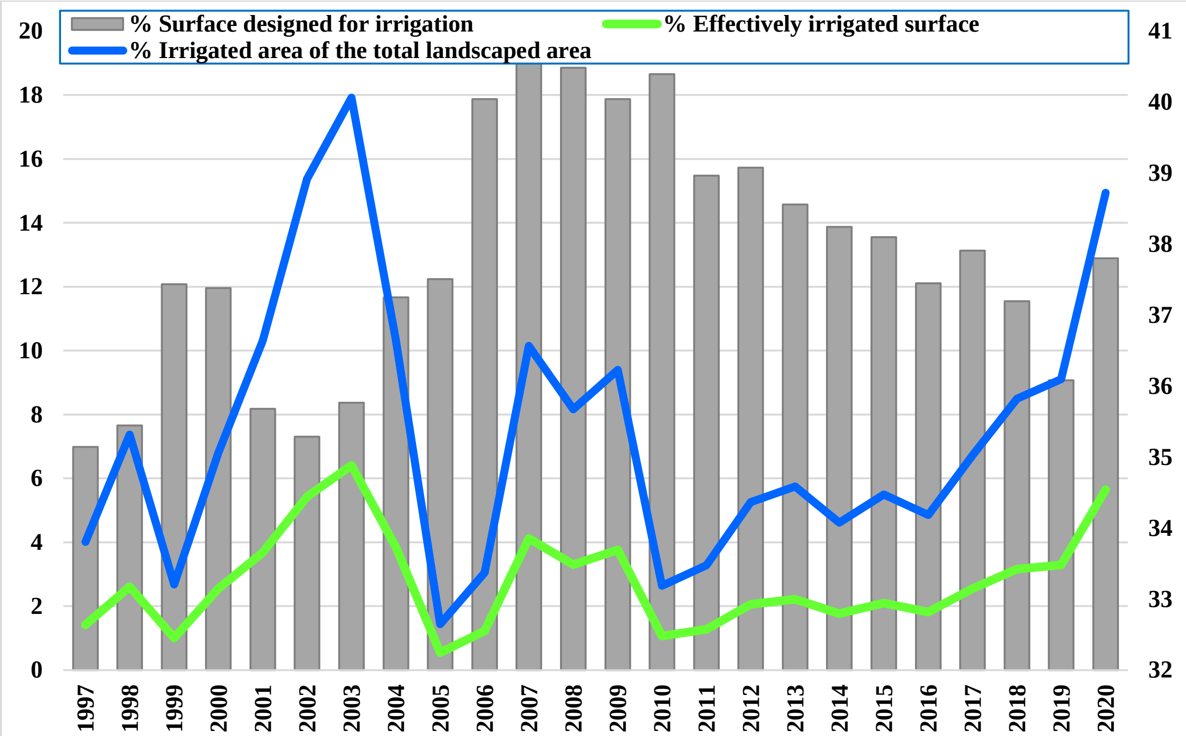

Figure 2. Evolution of the areas designed for irrigation and the effectively irrigated areas (%), historical data

Since 1997 and until now, a percent of 7.42% of the landscaped area and only 2.8% of arable area has been irrigated on average, representing 569,100 ha, the maximum level, in 2003 and 45,700 ha, the minimum level, in 2005. In the driest years of the last three decades, reduced areas have been irrigated, as follows: in 2000 – 85,000 ha (6.8%), in 2011 – 103,300 ha (3.3%), and in 2007, the year with the strongest drought, 320,200 ha (10.1%), causing huge harvest losses.

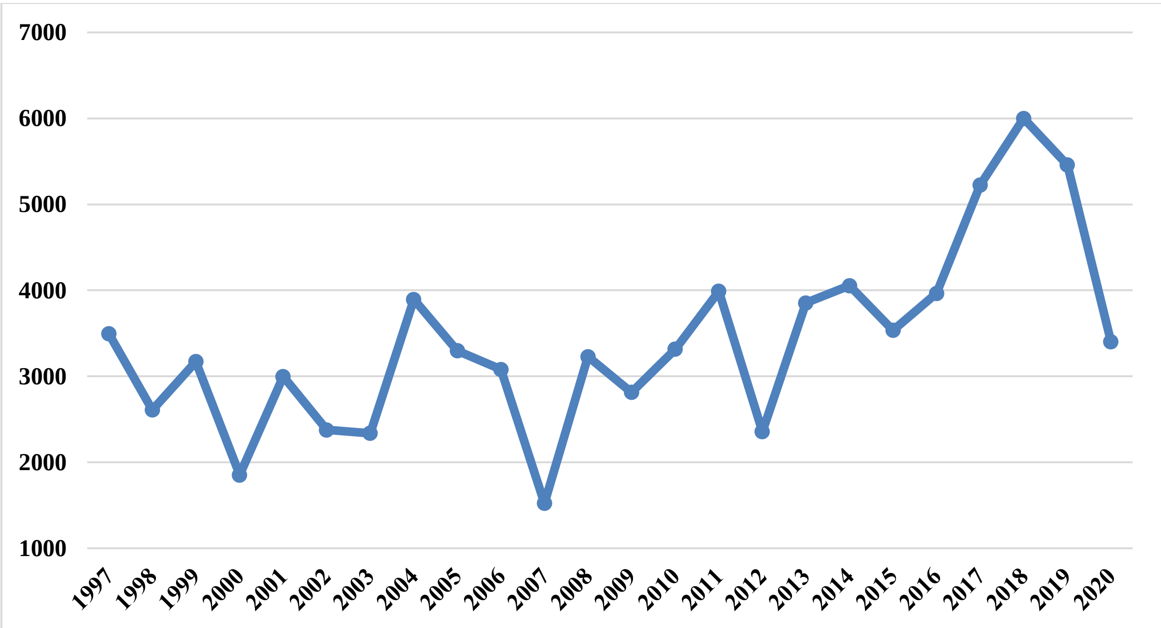

Figure 3. Evolution of the average cereals production (Kg/ha) – historical data

The average yields for the main cereals (wheat and corn) were of 1,853 kg/ha in 2000 and of only 1,523 kg/ha (equal or even lower compared to the average obtained for cereals in pre-war or interwar Romania) in 2007 (NIS, 2022), representing 22–25% of the average cereal yields of European countries (Rujescu et al. 2017) with ecological conditions similar and areas arranged for irrigation approximately equal to those of Romania.

In the figure below is shown the map of Romania in which the agricultural areas that are facing severe drought and that require irrigation are highlighted.

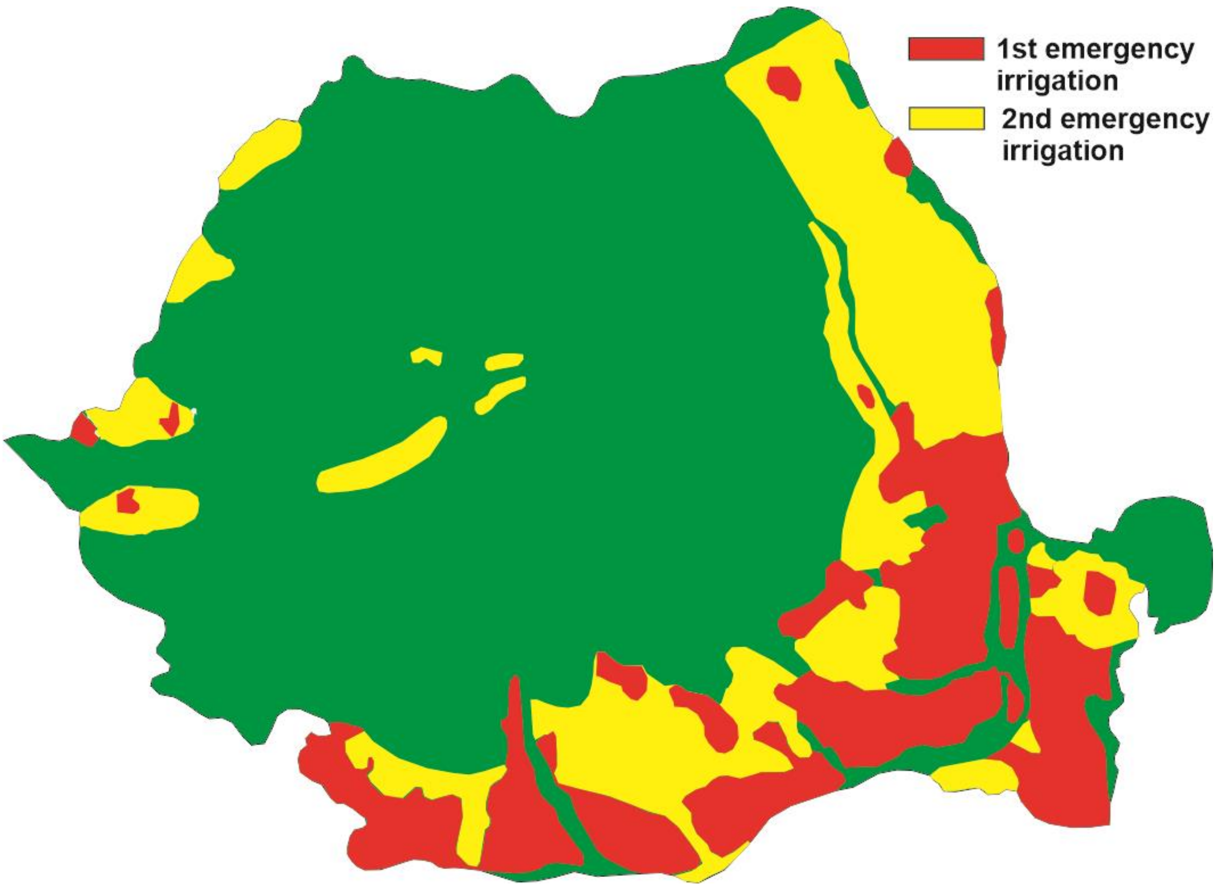

Figure 4. Areas affected by drought in Romania and which need irrigation

Source: Authors' calculation based by Agricultural Atlas of Romania, 2010

The weather dependency of cereal crops justifies the need to extend the irrigated area, as well as the correct application of irrigation to ensure the stability of plant production.

DISCUSSION

In Romania's climatic conditions, given the inadequate performance of agriculture, the refunctionalization and modernization of irrigation systems is one of the first investment priorities in the country's current agriculture.

In Romania, inland rivers are supplied mainly from rains and snows, and less from underground springs, which leads to a high degree of fluctuation of the flows during the year, so with great dependence and vulnerability to seasonal climatic conditions. The hydrological resource is unevenly distributed on the country's territory having a large variation not only seasonal (annual) but also from year to year (multiannual).

In the medium and long term, the satisfaction of water requirements of the population, industry, agriculture and other uses is not possible, in Romania, without carrying out large-scale hydrotechnical works, through which to accumulate the water needs in the periods abundant in precipitation and which would then be redistributed, in time and space, from the temporary accumulations in the reservoirs and inter-basin derivatives of flows.

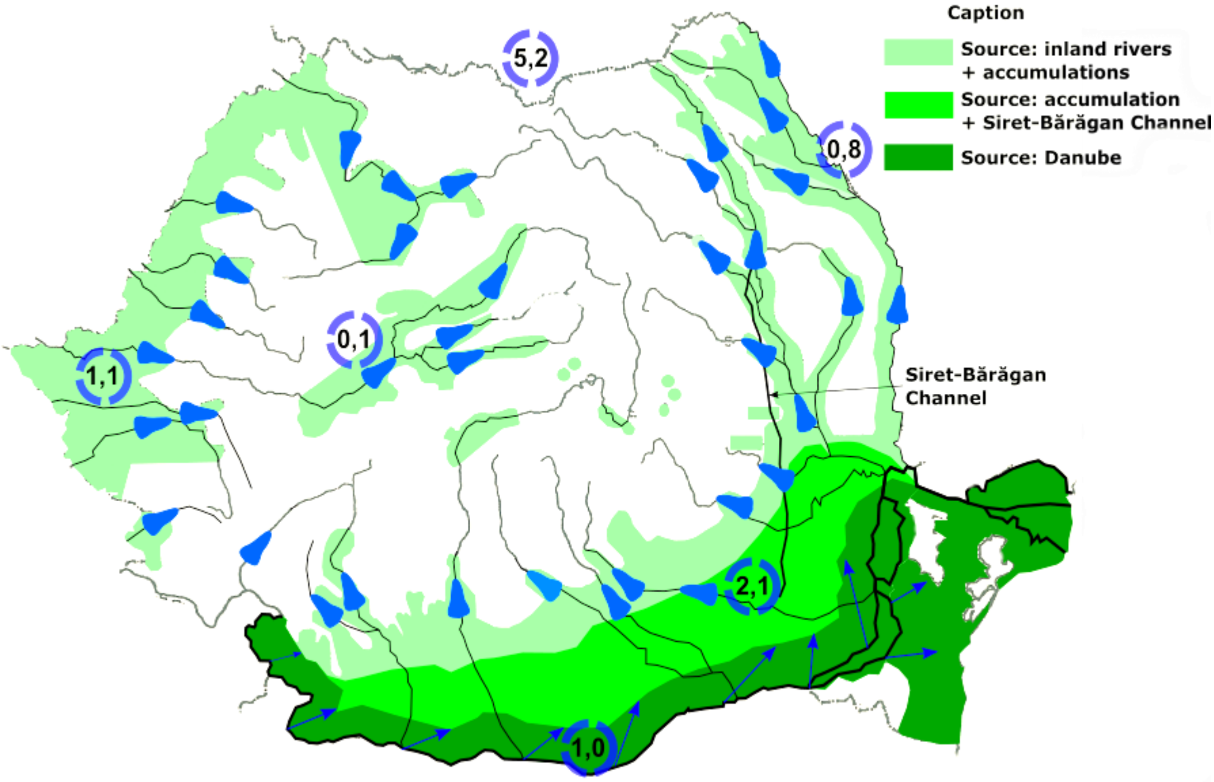

Figure 4. Land for irrigation and potentially irrigable (million hectares)
Source: Authors' calculation based by Agricultural Atlas of Romania, 2010

By creating reservoirs on the main river courses in Romania, as we propose in the map above, an important energy saving would be achieved compared to pumping water from the Danube in two or three steps to the agricultural land and would increase the irrigated area to 5.2 million ha.

Starting from the need to save water in increasing amounts, as well as from the prohibitive cost of water in the Danube, it is necessary to adopt other solutions for the application of irrigation in the current systems in operation and for the extension of new systems, including by resuming and completing the construction of the Siret-Bărăgan magistral channel, as a source of gravitational water for irrigation and major potency of river transport. Through the rehabilitated irrigation systems, it is necessary to apply watering methods with low water consumption and drip irrigation for crops that are suitable for these methods. The new irrigation systems, smaller in size compared to those made in the '80s, must be designed in another conception, which uses water from indoor sources (inland rivers, local accumulations, groundwater), by bringing, as far as possible, gravitational, with low energy consumption.

Water, which is a quantitatively deficient resource in Romania, will become increasingly reduced with the inadequate distribution of rainfall during the plant vegetation period, which is why the National Program for Agriculture must provide for: I) speeding up irrigation facilities; II) new techniques and technologies leading to the substantial reduction of water losses; III) increasing the coefficients for using water; (IV) to obtain the highest possible increase for each cubic metre of water used for irrigation; V) the organization of agroforestry curtains; VI) preserve vegetable, animal, microbiological biodiversity, through measures to prevent and combat losses; VII) increasing the amount of water used by temporary and permanent accumulation of precipitations.

For the area of 1.4–1.5 million ha, the difference up to the area arranged in the period before 1990, feasibility studies are required to establish the technical solutions of pumping-bringing water, the need for funds, their size and the sources of coverage as well as the profitability of the investment for water-using farmers. In the situation in which some systems cannot be rehabilitated by refurbishment and modernization, as is the case of the systems in the high plain of Dobrogea, it is necessary to renaturalize the respective agricultural territory, by setting up permanent meadows and forest plantations (protection curtains and forests).

In conclusion, we consider that the "0" investment priority of Romania's agriculture, which must be included first in all the strategic programs of Romanian agriculture and rural development (whether they are financed by internal, external, public and/or private resources), must be the investment in the rehabilitation and modern equipment of the irrigation systems.

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ANALYSIS OF VEGETATION DYNAMICS AND GEOMORPHOMETRIC VARIABLES IN THE RAKOS WATERSHED, HUNGARY

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ABSTRACT

Soil moisture plays a significant role in vegetation, climate, desertification of the land cover. Within the analysis of soil moisture indices, it is possible to structure the environmental planning system, land-use planning, and sustainable development strategies. The application of vegetation indices currently is one of the most efficient methods in producing information in local and global planning. Vegetation dynamics are dependent not only on meteorological factors, but also on soil and soil moisture dynamics. Geomorphometric variables, such as slope or aspect, can have a significant effect on such dynamics. The aim of study was to develop a time-series of Sentinel-2 derived vegetation indices (such as the Normalized Difference Vegetation Index (NDVI), and to compare the observed dynamics with the geomorphometric features derived from a digital terrain model.

Keywords: soil moisture, NDVI, Sentinel-2, vegetation, geomorphometrics.

INTRODUCTION

Topography is essential assessment of terrain features to represent the model of the landscapes. Topography is widely applied to reflect the terrain changes within the elevation regionally, therefore it impacts the hydrological, geomorphological, geographical processes on planet. The topographical features spatial variability including slope, reliefs, elevation manages the water transportation process on the land and soil simultaneously, impacting the climate, vegetation types and hydrological regimes changes. Geomorphometric variables are also named as a terrain attribute or geomorphometric parameters. These is a formation of land surface with a quantitative characteristic of derivatives from altitude as slope, curvatures, aspect, or any other compound variables like catchment area and topographic wetness index (TWI) (Florinsky et al., 2014).

Before the development of computer technology in 1990's the main source of topography was geographic maps, where the measurements and modellings were taken and processed manually (Florinsky et al., 2016). The era of geoinformatics development easened the processing of spatial analysis tools with the application of digital terrain models (DTM), which are derived from photogrammetry to calculate the slope of topographical metrics (Xia Li et al., 2020).

While the model of digital terrain represents a bare ground of the landscape, Digital Surface Model (DSM) pictures the height of vegetative patches as trees, also the human created objects as buildings. Therefore, Digital Elevation Model (DEM) is used as a variation synonym of DTM, but mostly it may describe both features of DTM and DSM. DEM is very often used in calculation and modelling of radar and photogrammetry images in remote sensing techniques (Hutchinson and Gallant et al., 2005).

NDVI is a Normalized Difference Vegetation Index is a calculation between the near-infrared (NIR) light reflected by vegetation and the visible light. NDVI was designed to simply detect living vegetation and distinguish it from other matters like rocks, soil, or seasonal decayed vegetation. NDVI derives from remoter sensing satellite imagery data, which is basically applied in crop evaluation within instrumental crop monitoring and modelling. NDVI calculates the state of plant on its light reflection at the specific frequency, the absorption and reflectance level of the specific waves (Fadzisayi M et al., 2021).

The purpose of the study is to represent the changes of vegetation cover in Rakos stream with the Remote Sensing satellite imagery dataset with the application of GIS tools. The calculation and assessment of the data is processed to explore the wetness index with TWI and vegetation index level with NDVI dataset collection and analysis. The collective data analysis is based on the results of Sentinel 2A sensor satellite images and DEM analysis of SRTM, OSM & Natural Earth source with the application of QGIS software tool.

MATERIAL AND METHOD

Rakos also known as Rakos-patak is a watershed stream in Hungary, Csongrad in the Eastern Europe. It is located at an elevation of 86 meters above sea level. Its geographical coordinates are 47°33'0" N and 19°4'0"E (Internet1). Rakos stream watershed is considered to be one of the most beautiful streams near the city of Budapest. Rakos stream is 44.3 km long with 185 km2 catchment area. The stream of Rakos watershed flows across Godollo, Isaszeg till Danube river in Budapest. The area between Godollo and Isaszeg is described with 12 ponds according to Szabo et al. The cities of Godollo and Budapest having the most concrete, but the area of Isaszeg is thickly covered plants. Rakos stream would be considered to be a great manageable place for tourism and recreation (Szabo et al., 2004).

The study area visual map is represented on the Figure 1 map with highlighted study area of Rakos watershed, including the main inhabited locations as Budapest, Pecel, Isaszeg and Godollo. The NDVI pixel data analysis was mainly done on the areas of Budapest, Isaszeg and Godollo. The pixel data with these three locations revealed the most different levels of vegetation cover. The results are followed in the section of results.

The methodology for data acquisition was applied by Remote Sensing (RS) and Geoinformation systems (GIS) techniques. NDVI data collection was obtained from USGS Earth Explorer website within Sentinel 2A imagery, In this paper the approach of alternative statistical modeling was applied to create a nonlinear relationships among remote sensing variables, as Sentinel Synthetic Aperture Radar (SAR) data, NDVI, DEM and TWI. NDVI images were created from the red and near-infrared bands in QGIS software using the spatial analysis module and the “raster calculator” tool.

The list of collected satellite images are by below table (Table 1.)

Figure 1. Image map of Rakos watershed study area (Source: Open Street Map, GIS User Community)

Table 1. The list of collected Sentinel 2A SAR satellite images

Sentinel 2A raster data name	Layer date
L1C_T34TCT_A009543_20190103T095535	NDVI January 2019
L1C_T34TCT_A018952_20190207T095153	NDVI February 2019
L1C_T34TCT_A019338_20190306T094249	NDVI March 2019
L1C_T34TCT_A019810_20190408T095031	NDVI April 2019
L1C_T34TCT_A020954_20190627T095541	NDVI June 2019
L1C_T34TCT_A021955_20190905T095319	NDVI September 2019
L1C_T34TCT_A022670_20191025T095100	NDVI October 2019
L1C_T34TCT_A022913_20191111T094345	NDVI November 2019
L1C_T34TCT_A026388_20200711T095034	NDVI July 2020
L1C_T34TCT_A022656_20210708T094032	NDVI July 2021
L1C_T34TCT_A034353_20220119T094346	NDVI January 2022

The dataset of Sentinel 2A images consist of 13 bands, where each band is 10, 20, or 60 meters in pixel size. The calculation of the NDVI indices were calculated by the application of bands 04 and 08, which are 10 meters resolution (Ayehu et al, 2019). The applied NDVI equation is:

$$NDVI = (B8 - B4) / (B8 + B4)$$

The NDVI data acquisition is to be analyzed to observe the most and the least vegetated areas in Rakos stream area. Three main locations of the watershed are to be analyzed, they are the cities of Budapest, Isaszeg and Godollo. The method of DEM model application is to calculate elevation level with the highest and the lowest points on the watershed. The dataset for DEM model was obtained via SRTM, OSM and Natural Earth source in QGIS software using the spatial analyst module and the raster calculator tool to provide detailed topographic information (Arnab Saha et al., 2018).

The projected DEM image was calculated into the TWI map that was acquired by the application of QGIS software. The index was applied in this research to measure the highest and lowest accumulated water bodies on the study area. The main calculation methods applied in QGIS software is raster calculator with tools of flow direction, flow accumulation, slope in degrees, slope in radiance. Areas with low TWI values tend to be drier comparing to the values with higher TWI values (Xia Li et al., 2020).

RESULTS AND DISCUSSIONS

NDVI data acquisition results with eleven Sentinel 2A SAR satellite image according to the Table 1. with classes of vegetation cover in the Rakos stream have revealed the highest vegetation cover in Isaszeg area of the study area. The pixel values of vegetation cover in Isaszeg area also is above zero level, whereas in Budapest and Godollo areas the minimum values are below zero. This can be explained by the highest amount of ponds in Isaszeg that has been described previously according to the research of Szabo (Szabo et al., 2004).

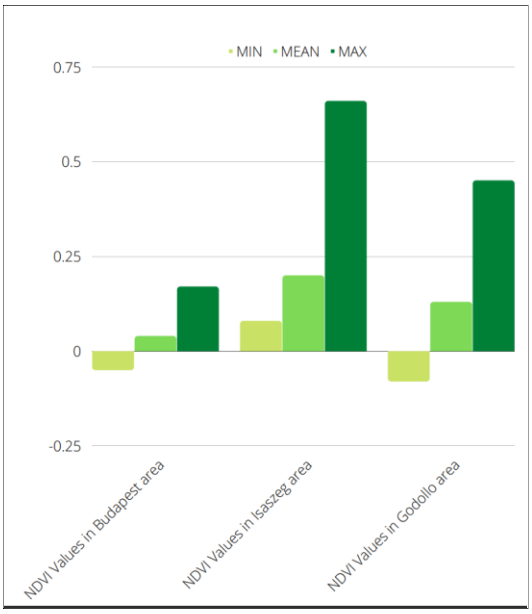

Figure 2. NDVI values in Budapest, Isaszeg, Godollo areas of Rakos watershed.

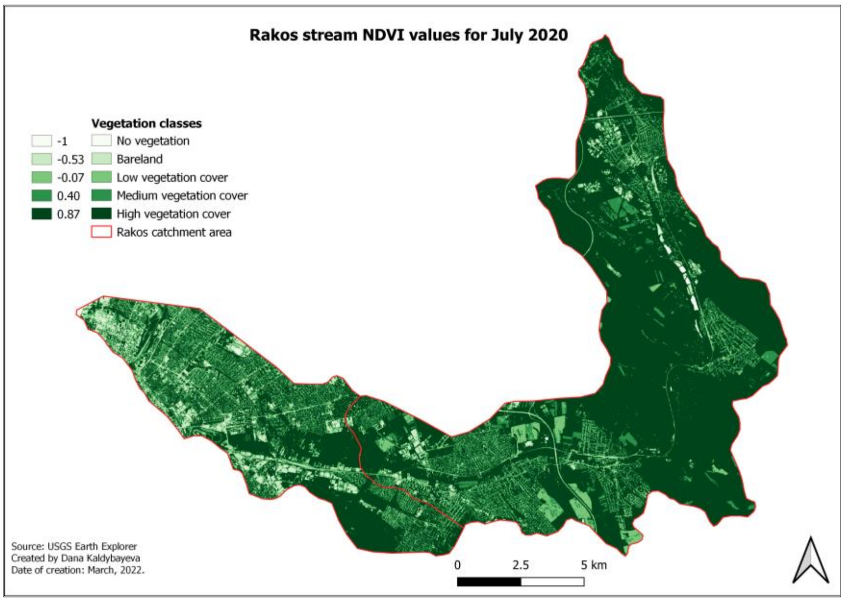

Figure 3. Rakos stream NDVI values for July 2020.

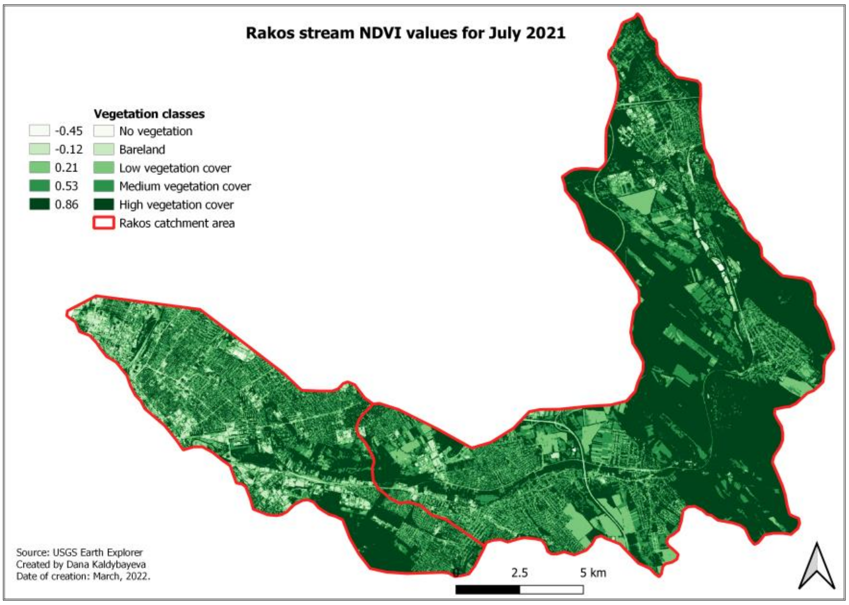

Figure 4. Rakos stream NDVI values for July 2021.

The color differences of the vegetation cover for Rakos watershed in figures 3 and 4 represent us the highest vegetation cover in Isaszeg area with 0.87 values in 2020 and 0.86 values in 2021. The map difference represent that in 2020 July the vegetation color pixels are higher in 2020 than in 2021. The lowest value in 2020 July is -1 and in 2021 July is -0.45.

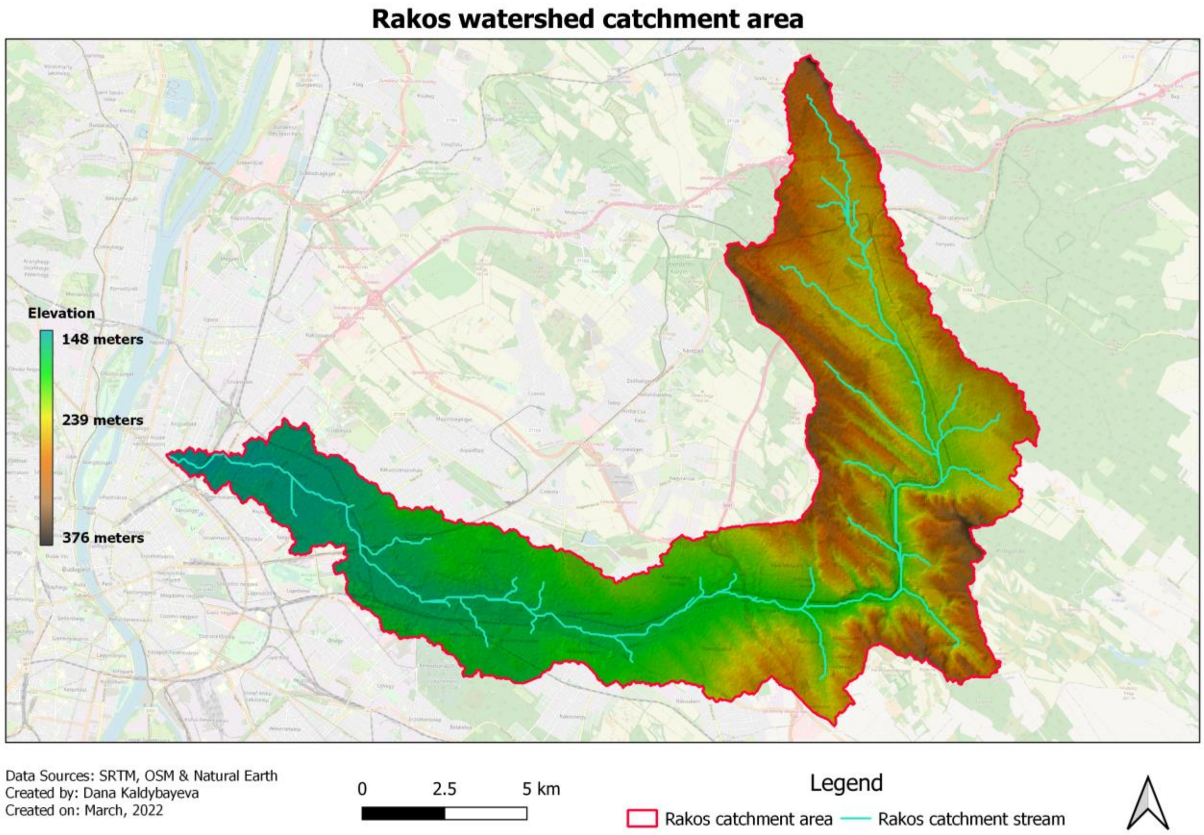

Figure 5. Rakos watershed catchment area DEM map.

Rakos watershed catchment stream is represented on the DEM map on the Figure 5. The hillshades from dark-brown till bright-blue color indicate the elevation level on the study area. The map represents the highest slope in the area of Godollo with 376 meters and the lowest in Budapest area with 148 meters. The shorter streams flowing from the hills model the main longest stream. The longest blue stream shows the catchment stream line that flows to Danube river in area of Budapest.

The topography wetness index values represented on the Figure 6. show the most vegetated areas with the lowest wetness index values. According to NDVI’s the most vegetated area of Isaszeg has the lowest wetness index value with 6.7 dark violet color range. The Rakos stream line represents the highest wetness index value with 22 red and 27 pink color ranges. The dark color range, indicating the lowest wetness level is visually high than the brighter colors of higher wetness index ranges.

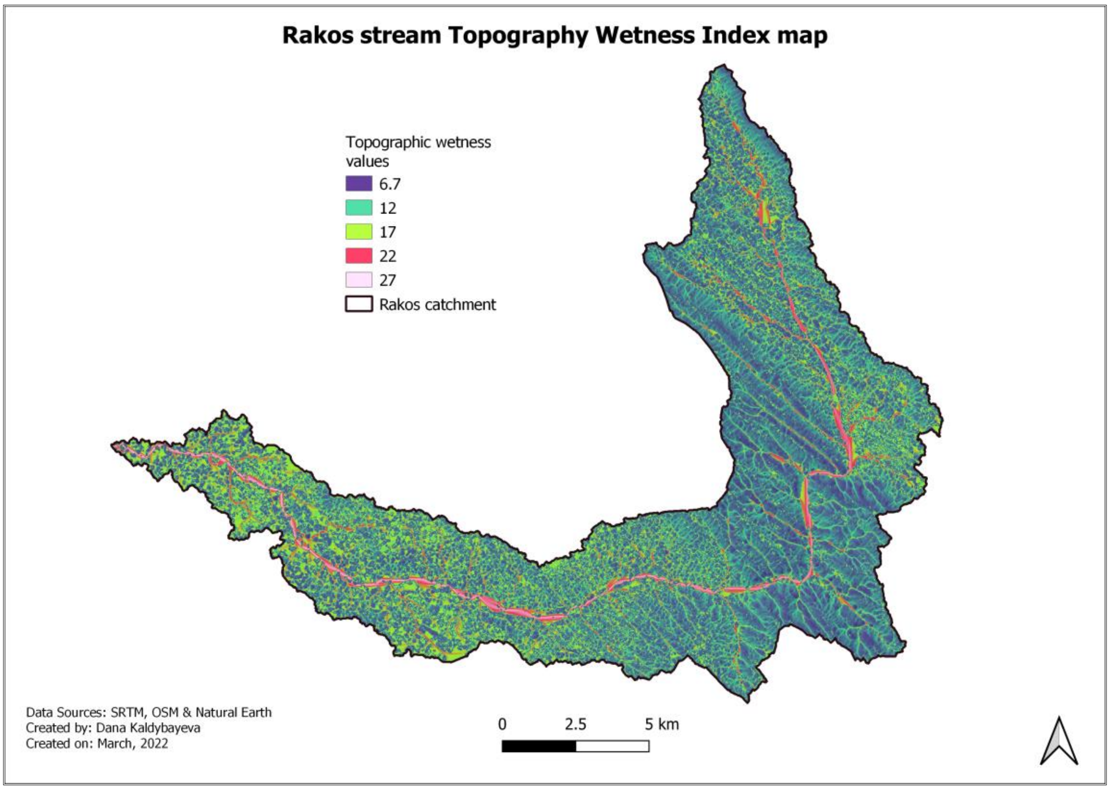

Figure 6. Rakos watershed Topography Wetness Index map.

CONCLUSIONS

The collected and processed data of NDVI, DEM and TWI can be further used and applied as a starting to continue the research work with modeling vegetation cover increasing or decreasing levels. Adding more data as soil moisture indices, temperature, and precipitation data can be correlated to verify more graphs and visual maps acquisition that can be used for the future Rakos watershed landscape development projects. The application of different softwares and data comparison to structure more precise pictures and modelings could be applied to follow the vegetation cover and wetness level changes in the study area of Rakos stream and apply for future watershed management and environmental prediction purposes.

Acknowledgments

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Abbreviations:

The following abbreviations are used in this paper:

- DEM: Digital Elevation Model
- DSM: Digital Surface Model
- DTM: Digital Terrain Model
- GIS: Geoinformation Systems
- NDVI: Normalized Difference Vegetation Index

NIR: Near-Infrared
TWI: Topography Wetness Index
RS: Remote Sensing
SAR: Sentinel Synthetic Aperture Radar
USGS: United States Geological Survey

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A REVIEW ON IRRIGATION TECHNIQUES AND THEIR PERFORMANCE IN TANZANIA AGRICULTURAL SECTOR

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ABSTRACT

Irrigation has an important role to play in agriculture, amid total concerns over rising food production for many sub-Saharan African countries. It is also a key strategy to enhance economic growth and tackle rural poverty. This paper was conducted to highlight several irrigation techniques practiced in Tanzania's agricultural sector and their performances in agriculture. Data in this poster were collected from published research papers from 1994 to 2022, Tanzania government reports, and research projects. The results show that Tanzania's irrigation system varies from cultural–environmental adaptations/traditional methods; widely practiced in rural areas to modern irrigation techniques which are mainly practiced in agribusiness fields. Traditional techniques have been reported with good performance and manageability, especially in small household farming although people have recently adopted modern irrigation techniques. Modern irrigation technologies are described with a small degree of success in northern and southern parts of Tanzania. Even though there have been emphases on applying advanced irrigation technologies, the performance is still low. Irrigation education, strong government support, and empowerment are proposed as possible solutions towards a better performance in modern agriculture.

INTRODUCTION

With the global concerns over rising food, climate change, and changing diets, agriculture has reappeared on the development program. Irrigated agriculture is determined to play an important role in rising food production in uncertain, resource-limited semi-arid and sub-Saharan countries like Tanzania. It is also a key strategy to enhance economic growth and tackle poverty in rural societies (Oates et al., 2017). Tanzanian agriculture is primarily reliant on seasonal rainfalls, which are gradually decreasing from season to season (Levira, 2009; Oates et al., 2017; Wambura et al., 2014).

Both northern and eastern parts of the country have two rainy seasons – the long rain season in March to May (Masika) and short rains in October to December (Vuli). The rest of the country has a single rainy season from October to April – to May (McSweeney et al., 2010; URT, 2014).

Even without taking into account the high evaporation rates that often exceed average annual rainfall, rainfall alone is insufficient to maintain many crops to maturity (Makurira et al., 2007). Irrigation is considered to be the most logical way to reduce the effects of dry spells (Makurira et al., 2007). Irrigation development is recognized as among the essential techniques for ensuring agricultural expansion and food security in Tanzania (Nkonya, 2013).

Tanzanian irrigation farming system can be divided into three main categories: Traditional smallholder irrigation, modern small scale holder irrigation schemes, and large-scale irrigated public/private farms (Mrema, 1984). The traditional approach is applied to grow a variety of vegetables as well as other crops like wheat, sugar cane, barley, and maize (Mkavidanda & A.L.Kaswamila, 1994).

Traditional irrigation schemes are mainly practiced in all parts of Tanzania especially rural areas and incorporated into a profitable and highly productive year-round farming system (Mkavidanda & A.L.Kaswamila, 1994). Modern small-scale holders and large-scale irrigation schemes are in most cases planned and constructed by the central/ local government and private or parastatal companies respectively (Kaswamila and Masuruli, 2004; Mkavidanda & A.L.Kaswamila, 1994). Some findings have revealed that most households in some parts of Tanzania practice and adopt modern irrigation schemes in cultivated large tomato and onions farm size as compared to traditional irrigation schemes although.

The existing findings on irrigation techniques and their performance in Tanzania's agricultural sector at the national level are fragmented and somewhat outdated while the available findings focus more on water use linked conflicts among water users. Therefore, this review aims to assess the status of irrigation techniques practiced in the agricultural sector, related performances, and challenges facing the sector across the country.

Irrigation Techniques and their Performances in Tanzania

In Tanzania's 2010 National Irrigation Policy identifies four different categories of irrigation: traditional irrigation schemes, improved irrigation schemes, rainwater harvesting irrigation schemes, and large-scale/commercial irrigated farms (URT, 2010). Both modern small scale holder/village irrigation schemes and large-scale irrigated private/public farms are concentrated mainly in the mountainous eastern and south-western regions including Mbeya, Kilimanjaro, Tanga, and Morogoro, whereas traditional irrigation has succeeded as well in some parts of Arusha, Iringa and other rural areas across the country (Nkonya, 2013). Modern and traditional are dominating irrigation policies and are shaping interventions in Tanzania (de Bont et al., 2019), although farmer-led irrigation development also has been reported as an important process in the expansion of the irrigated area in the Kilimanjaro Region (de Bont et al., 2019).

Most irrigated agriculture is on small scale and managed by farmers, although a few largest schemes have been developed, such as Mbarali (3,000 ha), Dakawa (2,000 ha), and Kilombero commercial rice farm (Oates et al., 2017). Many researchers have reported irrigation practices run by farmer cooperatives and the government to be ineffective, unsuccessful, and dysfunctional in Tanzania (ZHANG et al., 2021). *Vinyungu* irrigation system, as a form of improved traditional irrigation, has been practiced in Iringa rural district in the southern highlands of Tanzania with a great potential in generating income for farmers and in ensuring food security yearly although its longevity has been difficult to maintain (Mkavidanda & A.L.Kaswamila, 1994).

Apart from traditional practices which mostly rely on surface (gravity) irrigation, drip and sprinkler irrigation are less dominant in the country and the past was largely introduced on commercial farming (FAO, 2005). Although there has been an increased rate of application of drip irrigation across the country to improve the living standard of people yet ensuring the process is both sustainable and efficient for the sector remains a challenge (Mdee et al., 2014).

A low-cost drip irrigation system was performed in Mkindo village and tested for its acceptability, performance, and affordability under farmer-managed settings and the result showed better performance on an economic base and farmers defined a high level of satisfaction compared to conventional drip irrigation systems (Kahimba et al., 2015).

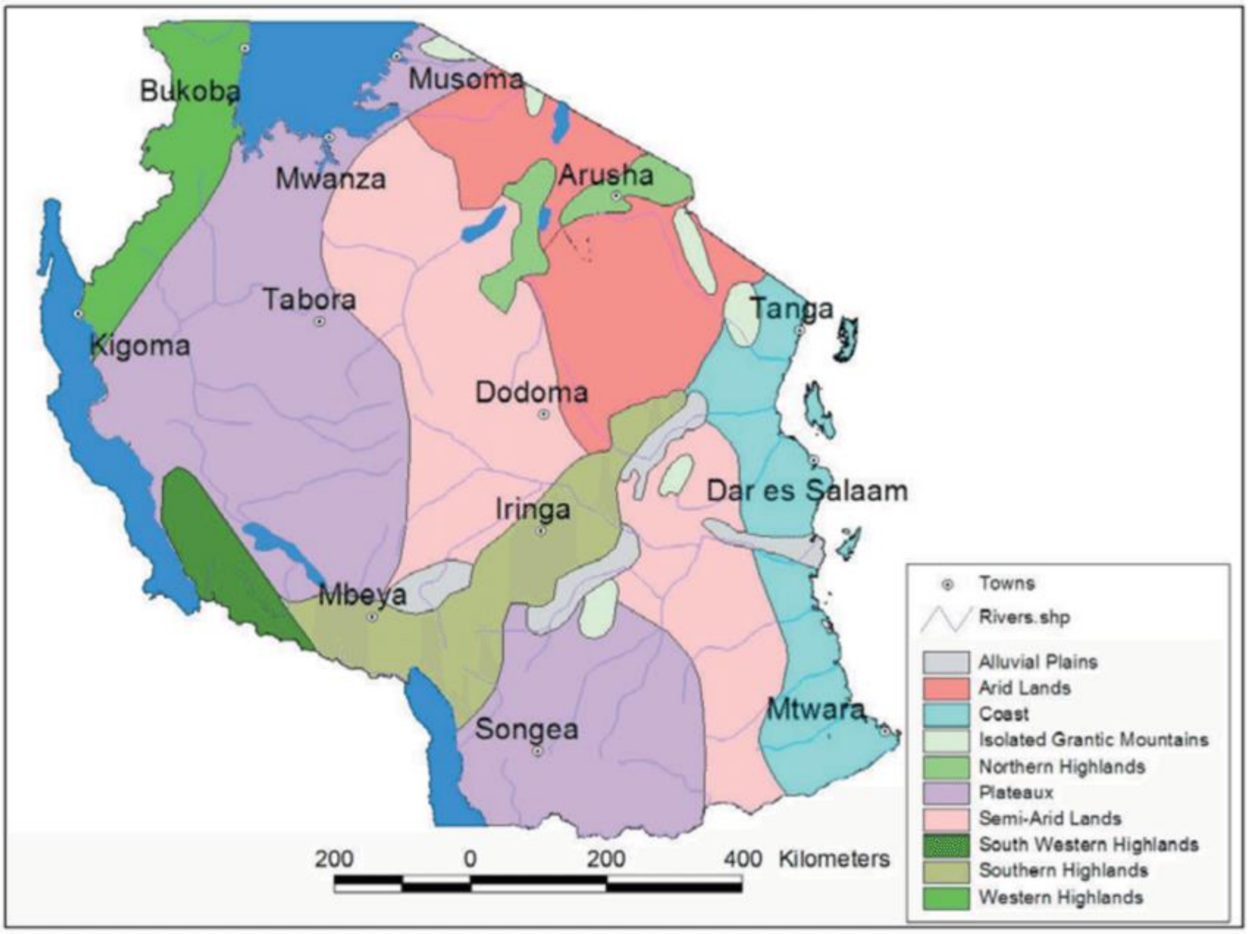

Figure 1. Tanzania's Agro-ecological zones
Source: Modified by (Malozo, 2018)

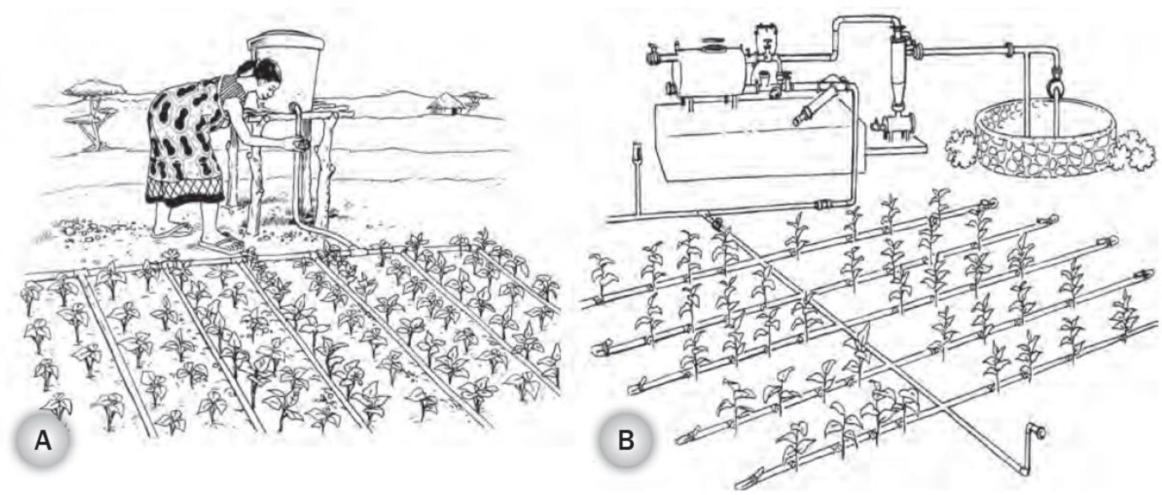

Figure 2. (a) Low-cost drip irrigation system and (b) conventional drip irrigation system in Mkindo village, Morogoro region - Tanzania (Kahimba et al., 2015).

A field experiment containing six drip irrigation treatment setups was performed in Iringa region to determine the effects of drip irrigation on the tea yield and crop water productivity responses whereby the results showed that drip irrigation increased yields and gave water-saving benefits of up to 50% from the application of 50% less water to remove the soil water deficit and also provided labor-saving of 85% for irrigation (Kigalu et al., 2008; Möller & Weatherhead, 2007). The sprinkler irrigation system has been performed in the Kagera region, Tanzania to test its effect on sugarcane yield related to pivot and influence of soil properties in which the findings reported that poor soil properties and pivot performance greatly reduce sugarcane productivity (Reuben, P. M.1, Mahoo, H.1, Thadei, S.Y.1 & Ernest, 2010). The research was conducted in Northern Highlands, Arusha -Tanzania to access the influence of drip irrigation on banana bunch yield and growth and the result showed that drip irrigation improves banana growth and reduces water losses (Kibona & International, 2020).

Another research was conducted on the applicability of drip irrigation for smallholder farmers (305 respondents) in the northern part of Tanzania in which the results indicated a significant difference in yields for farmers using modern irrigation techniques as compared to traditional methods, the findings reported that although traditional irrigation still dominates there is a good response to adoption towards modern irrigation techniques (Msuya, Kassim Jumanne, 2016).

Table.1. Most common irrigation types in the study area (n=305). (Msuya, Kassim Jumanne, 2016)

Type of Irrigation	Frequency	Percentage
Flooding	101	33
Can watering	58	19
Flooding & pump	52	17
Flooding & can	15	5
Drip irrigation	35	11
Sprinkler	11	4
Drip & Sprinkler	16	5
Flooding, drip & sprinkler	17	6
Total	305	100

Table 2: Irrigation methods used (n=65) (Mwatawala & Mariki, 2016)

Method used	Number	Percentage
Surface irrigation	57	87.7
Drip irrigation	6	9.2
Sprinkler irrigation	2	3.1

Table 3: Source of water, reliability, and adequacy (n=65) (Mwatawala & Mariki, 2016)

Type of Irrigation	***Frequency***	***Percentage***
Source of water	11	16.9
Well	5	7.7
Borehole	49	75.4
Runoff catchment dams/reservoir		
Reliability and adequacy		
Yes	50	76.9
No	15	23.1

Table 4: Schemes developed by 2001: Classification of the scheme by management type.

Type of Irrigation	**Management type**			**Total**	**Total irrigable area (ha)**
	Smallholder	**Private**	**Others**		
Traditional irrigation	924	52	6	982	518,745
Water harvesting	204	1	0	205	150,720
Modern irrigation	95	25	8	128	134,582
Improved traditional irrigation	105	7	1	113	50,246
Total	1328	85	15	1428	854,293

Source: Ministry of Agriculture and food security (2002)

Table 5: Percentage of farmers in different economic activities (Mkavidanda & A.L.Kaswamila, 1994).

Village	Activity			
	Rainfed	**Vinyungu**	**Livestock**	**Others**
Uhominyi	100	85	65	20
Wasa	100	100	82	53
Kihanga	100	100	61	33
Lulanzi	100	93	69	31
Kising’a	95	92	40	35

Source: Field data November 1998

Challenges facing Irrigation practices in Tanzania

Outcomes and technical performance relatively depend on how irrigation is practiced in a given area. In a broad aspect, the term can include consideration of coordination, scheme management, and other inputs associated with the practice, such as access to agricultural inputs, technical assistance, and markets. In Tanzania, external factors such as environmental change and market signals influence the irrigation sector but yet practices and government policies shape most determine the performance. Irrigation practice in Tanzania has been affected by poor strategy and policies embedded within a political context. (Mkavidanda & A.L.Kaswamila, 1994; Oates et al., 2017). According to JICA 2002, Tanzania's irrigation sector suffers from unsound logic in project design and weak linkages between purpose and outputs of projects, a scarcity of participatory approaches that are relevant, misinterpretation of the term "simple and low-cost technology", Inadequate planning, design, and construction supervision standards and manuals (Oates et al., 2017; URT, 2014). There are no processes in place to provide feedback on the lessons learned from implementing irrigation projects, lack of human resources and active participation of local government authority in irrigation development strategy, The need for a more effective support system to water user associations'/irrigation groups' activities and interestingly, there is no explicit mentioned here of water resources per se, indicating that in Tanzania, water availability is not perceived as a key constraint (Levard, 2014; Oates et al., 2017).

Meanwhile, efforts to build a modern irrigation system have been costly and provided poor results. Much larger plans have failed to reach their full potential, and several major issues remain unsuccessful.

CONCLUSION

Tanzania has a long history of informal or traditional irrigation built by smallholder farmers and administered through customary arrangements. Tanzania's irrigation expansion has strengthened national food security over the last 20 years, and it plays a significant role to improve the economy of the farmers although elimination of rural poverty remains the target of the government policies. Challenges in the irrigation sector are complex, the result of various technical, political, and ideological factors. Irrigation policies and practices in Tanzania are mostly defined by the political will which lacks proper implementation, advanced strategic plans, and long-term plans. Government implemented projects have the least performance compared to private/external funded irrigation projects. Traditional or improved traditional irrigation is dominant in many regions, nevertheless, modern irrigation has been practiced in some parts of Tanzania with average performance. A range of solutions at different scales will be key to improving the performance of the irrigation sector in Tanzania including both managerial and technical but more connected to institutional environment or political which could be challenging to implement.

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THE INFLUENCE OF AMMONIUM PRESENT IN SURFACE GROUNDWATER FROM GRADINARI VILLAGE, CARAS SEVERIN COUNTY, ROMANIA, ON THE MITOTIC DEVELOPMENT CYCLE IN *ALLIUM SATIVUM* L.

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ABSTRACT

The cytological analysis of the cell cycle in garlic was followed, under the influence of surface groundwater from a well in Caras Severin County and used as drinking water, with a higher ammonium content; in order to identify certain chromosomal aberrations at the cellular level, due to the fact that the plant biological material was obtained by hydration with this type of water. It is necessary to find solutions for water purification, because the cytological analyzes performed on the mitotic cell cycle in *Allium sativum* L., indicate chromosomal aberrations due to its presence in a higher concentration than normal ammonium.

Keywords: water polution, plant organism development

INTRODUCTION

Germplasm is a collection of genetic resources for an organism, and also underlies the physical heredity and is transmitted from one generation to another through germ cells. (Ramanatha si Hodgkin, 2002) Plant bioassays are the most sensitive in detecting environmental hazards of water and can serve as a first indication of their presence. (Petcov (Uzun) A. et al, 2008; Camen D.et al, 2016) Natural water is never pure. It contains a number of both chemical and biological elements that characterize it and which are considered, to a certain extent, natural elements. (Zektser, I.S., & Everett, L.G., 2000)

Geographically, Caraş-Severin County is located in the southwestern part of Romania, Caraş-Severin County has an area of 8,520 km^2, which represents 3.6% of the country's area. In terms of size, Caraş-Severin County is the third in the country. (www.oravita.ro)

From the point of view of the waters, in Caraş-Severin the hydrographic network extends over the surface of 3273 km. (www. eco.aqua.ro). The presence of high concentrations of ammonium in water has a number of negative consequences on the human body, animals and plants. (Miller & Tyler, 2002; J. K. Bohlke et al, 2006)

MATERIALS AND METHODS

In the villege of Grădinari there are wells in the courtyards of the people who supply the households with drinking water. There are approx. 15 wells dug at a depth ranging between 8-14m, with diameters of approx. 1.0-1.20 m, built with stone or brick and provides with wheel and bucket for water extraction.

In order to monitor the ammonium content in the surface groundwater, we collected water samples from a depth of 8 m, from Grădinari locality, Caraş-Severin county, Romania. (Fig 1; Fig.2)

Figure 1 Location of water sample collecting point location in Caraş-Severin county (red dot) (www.wikipedia.ro)

Figure 2 Sample collecting point at Grădinari (original)

The data presented were collected by quarterly trips to the location. The description of the natural environment is made by own observations and by the information gathered from the locals (*Table* 1)

Table 1. Description of natural area surrounding the sample collecting point at Gradinari location

Location	In the center of the village
Technical description of the well	It is 8 m deep, the water distribution being done manually
How to operate	Families in the neighbourhood of the well use the water in the household
Water use	The water is used for household and drinking purposes

Table 2. Amonium content in the samples collected from inland surface waters Grădinari location

Nr.crt.	Location/sample collection depth	Month				
		February 2021	May 2021	July 2021	October 2021	December 2021
		mg / l				
1	Grădinari -8 m	0,96	0,83	0,79	0,54	0,61

*AML=Maximum allowed value

The ammonium content in Grădinari locality, at a depth of 8 m, exceeded the maximum allowed limit (AML) of almost 2 times (0.96 mg / l), in February. (*Table* 2)

The biological plant material used to analyze the tolerance to stress with ammonium content present in the surface groundwater is garlic bulbs (puppies) of the local landraces of Cenad, Timiș County. 6 experimental variants were used:

V1 - control, 2 liters of distilled water;
V2 - water collected for October 2021;
V3 - water collected for December 2021;
V4 - water collected for July 2021;
V5 - water collected for May 2021;
V6 - water collected for February 2021.

The experiment was mounted in clear glass vessels. (*Figure* 3) At 6 days after the appearance of the roots, when the process of growing in length of the roots has greatly diminished, samples were collected for cytological analysis.

Figure 3 Experimental variants

The biological material was fixed in Carnoy II fixative (ethyl alcohol 3: glacial acetic acid 1). Hydrolysis was performed with 1 N HCl at 60°C for 18 minutes. Staining was performed with Schiff's reagent (basic faded fuchsia) for two hours at 4°C. Squash (temporary) preparations were made. The phases of mitosis were followed by recording the number of cells in the different phases of division and chromosomal aberrations.

RESULTS

Cytogenetic analysis was performed 6 days after the start of the experiment. It was noted that in the Control variant the mitotic division was active, most of the cells being in prophase, 8% in metaphase, 74% in anaphase and 98% in telophase. In variant V5, V6, mitotic division was inhibited, the number of cells in the mitosis itself being reduced by almost half compared to Control. Most of the cells (94.9%) were in prophase and only a very small percentage in the other phases of division (*Table* 3).

In variant V3, V4, the division was strongly inhibited, a very small number of cells being in mitosis proper, all in prophase (approximately 10 cells / meristem compared to 184 cells / meristem in Control).

No cells were found in other division phases. Mitotic division was completely inhibited in variant V2, 6 days after the start of the experiment. All the analyzed cells had undergone a process of plasmolysis, due to the high concentration of ammonium in the water and implicitly in the cytoplasm. Most of the cells analyzed were in the G1 stage.

These results, according to which the roots subjected to stress provide for the moment a smaller amount of substances to the stem, disturbing the balance of the substances and causing the increase of the rigidity of the cell walls, the multiplication of the cells decreases.

In variants V2 and V3, chromosomal aberrations and genomic mutations were noticed, induced by the high ammonium concentration: fragments in prometaphase, metaphase, anaphase; bridges in anaphase and telophase, binucleate cells and micronuclei in the interphase. (*Figure* 4).

Table 3. The cytologic analysis

Var.	Cells in mitosis									
	No. roots	Total cells in division analyzed	PROMETAPHASE		METAPHASE		ANAPHASE		TELOPHASE	
			NR.	%	NR.	%	NR.	%	NR.	%
V1	10	1468	1098	74.8	118	8.0	108	7.4	144	9.8
V5 V6	10	826	784	94.9	16	1.9	10	1.3	16	1.9
V3 V4	10	79	79	100	0	0	0	0	0	0
V2	10	0	0	0	0	0	0	0	0	0

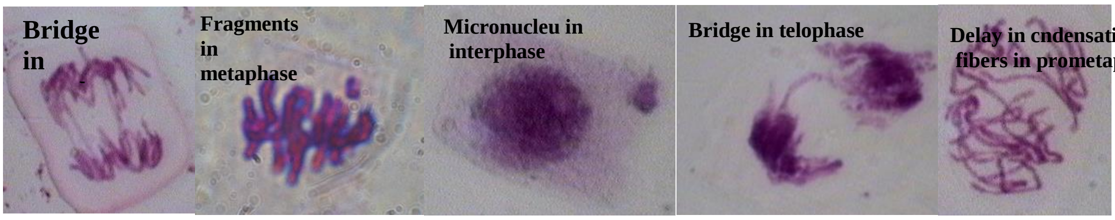

Figure 4. Cytological effect of the amonium content

DISCUSSION

1. Pollution with ammonium compounds of surface waters occurs due to the influence of several factors, some of which we mention:
   a) the passage of water through areas with soluble rocks
   b) the passage of surface waters through areas with soil erosion processes.
   c) development of hydrophilic and aquatic vegetation.
2. Cytogenetic analysis revealed a decrease in root mitotic activity with increasing ammonium concentration in water.
3. The concentration of 0.96 mg / l is cytotoxic indicating cell plasmolysis.
4. From all the experimented variants, the seedlings better adapted for further cultivation in vegetation pots were selected, under conditions of controlled stress.

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CHARACTERISTICS OF GROUNDWATER LEVEL IN THE SZARVAS-BÉKÉSSZENTANDRÁS OXBOW SUBBASIN

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ABSTRACT

The shallow groundwater has a direct and indirect effect on natural vegetation and agricultural production. The decline in groundwater level (GWL) can have negative impacts. In many areas in Hungary decreasing GWL trends in the last decades were found by earlier studies. In our research we studied the characteristics of groundwater level focusing on our study area, the subbasin of Szarvas-Békésszentandrás Oxbow. We analysed 20 years daily data of groundwater level of eight monitoring wells. Annual course and long term tendencies of groundwater level were examined. In average of 16 years the GWL reaches its maximum in April and its deepest level in autumn (September, October and November depending on the station). Four typical groups of groundwater level courses could be distinguished based on the average depth and seasonal variations of GWL. The year to year GWL variability is larger in January and April compared to July and especially to October. The trends of the middle months of the seasons are almost the same in significance and slope compared to the trends based on yearly mean time series. The differences in trends can be found between stations rather than between the months used for calculations. The larger part of the subbasin can be characterised by decreasing trend in groundwater levels (2002-2020). The change exceeds 1 m at station Szarvas 2832 (144 cm) and Szarvas 2778 (122 cm). However, there is a station with no significant trend, GWL at Csabacsűd 2779 station shows relative stability in yearly average, which is valid for some areas in the eastern part of the subbasin.

Keywords: groundwater level, trend, long-term, annual course

INTRODUCTION

The shallow groundwater has a direct and indirect effect on natural vegetation and agricultural production. High levels of groundwater increases the risk of inland excess water. In case of optimal level the groundwater can significantly contribute to the water supply of plants. This optimal level depends on the crop species, soil type and meteorological conditions. The decline in the groundwater level can result in loss of this positive effects. Such a phenomenon can be observed in many regions caused by the climate change. In our study we focus on these questions related to our research area, Szarvas-Békésszentandrás Oxbow Subbasin.

In the lysimeter groundwater experiments, the optimum level was at 1 m depth for field crops (wheat, maize, sugar beet, alfalfa) and higher (0.5 m) for grasses, where the average yield reached values of irrigated treatments. In deeper-rooted plants, the effect of decreasing groundwater level occurs more slowly, as they are able to absorb water from deeper groundwater (*Szalóki 1994*). From the groundwater, the water enters the upper layers of the soil mainly through capillary water lifting (*Pálfai 1996*).

High groundwater levels can help or cause the formation of inland excess water (*Réth áti 1983*).

Rising groundwater levels can bring harmful salts to the soil surface, which can cause secondary salinization. If the upward water movement can be changed to a downward one by some technical solution (e.g. drainage), then the salinity in the given place can be kept at the leaching stage or in equilibrium even at a higher than critical groundwater level (*Molnár and Winter 1983*).

The change of groundwater level is influenced by meteorological factors (precipitation, temperature, evaporation) and human activity (water extraction, irrigation, sewerage) (*Yan et al. 2021, Li et al. 2020)*. Near watercourses, groundwater level follows the water level of the surface water (river) (*Stelczer 2000*). An increase in groundwater levels may occur as a result of irrigation and leakage from irrigation channels (*Molnár and Winter 1983*).

Groundwater levels change periodically throughout the year. Annual and daily fluctuations in the vertical movement of the groundwater level are observed (*Hu et al. 2011*). The general seasonal course in water level in Hungary has a spring maximum and an autumn minimum (*Rétháti 1983*). *Nyizsalovszki and Szabó (2003)* showed two minimum in the groundwater level in Tokaj-Hegyalja during the year, a smaller minimum at the end of summer (August-September) due to lack of precipitation, evaporation loss, water uptake by plants, and then as an organic continuation, a stronger minimum late autumn-early winter minimum, that occurred during November-December. It was caused by low rainfall during the measurement period. The maximum values occurred in the spring (March-April). There was a strong correlation between the amount of precipitation and the fluctuation of the groundwater.

In the studies of *Kovács and Turai (2004)* the result for the Mátra-Bükkalja area the groundwater level basically depends on precipitation conditions. It was also found that the extraction of mining water and the changes of confined aquifers have no influence on the groundwater level. However, according to other Hungarian studies the intensive water withdrawals from the confined aquafer reduces the amount of shallow groundwater (*Pálfai 2010*). In another study of Mátraalja-Bükkalja area the groundwater level reached its maximum values in April-May during the year (*Kovács 2014*). There was no direct correlation between the monthly precipitation and the groundwater level depth in the given month. The maximum groundwater level of each well occurred only 0.6–1.2 years after the occurrence of precipitation maxima, depending on the depth of the average groundwater level in the wells. The time shift is longer if the groundwater level is deeper (1.5-3 m water depth: 0.7-0.9 years, 3-4 m water depth: 1.0-1.4 years).

In areas with different climatic conditions *Abliz et al. (2016)* also found seasonal fluctuations in groundwater level in Northwest China, with the shallowest groundwater levels in spring, sinking during summer and autumn, due to evapotranspiration and extensive agricultural water consumption. *Hao et al. (2017)* observed a continuous decline in groundwater levels in China as a result of long-term water extraction.

In Hungary between the Danube and the Tisza rivers, in the north-western observation wells (Ócsa, Ladánybene), the groundwater level decreased significantly between 1940 and 2008. The measurements showed a decrease in the groundwater level in the southern part of the Danube-Tisza area (around Rém) and in the area of Ásotthalom, too, regarding the long-term series data. Annual fluctuations can be detected in the water regime of the Öregcsertő observation well in the floodplain of the Danube, but it does not show a trend-like change (*Szalai 2011*).

In our research the characteristics of the groundwater level (especially the average seasonal course and long term tendencies) was examined in the subbasin area of the Szarvas-Békésszentandrás Oxbow using time series of 8 monitoring wells (2002-2021).

MATERIALS AND METHODS

The study area of our research, the Szarvas-Békésszentandrás Oxbow Subbasin is located in the middle part of the Hungarian Great Plain. The area is almost totally flat. The elevation above sea level is typically between 82 m (near river, oxbow) and 86 m (at loess areas in the eastern part). The 8 groundwater monitoring wells which data were used in the research are located within a distance of 15 km from town Szarvas (*Figure 1.*).

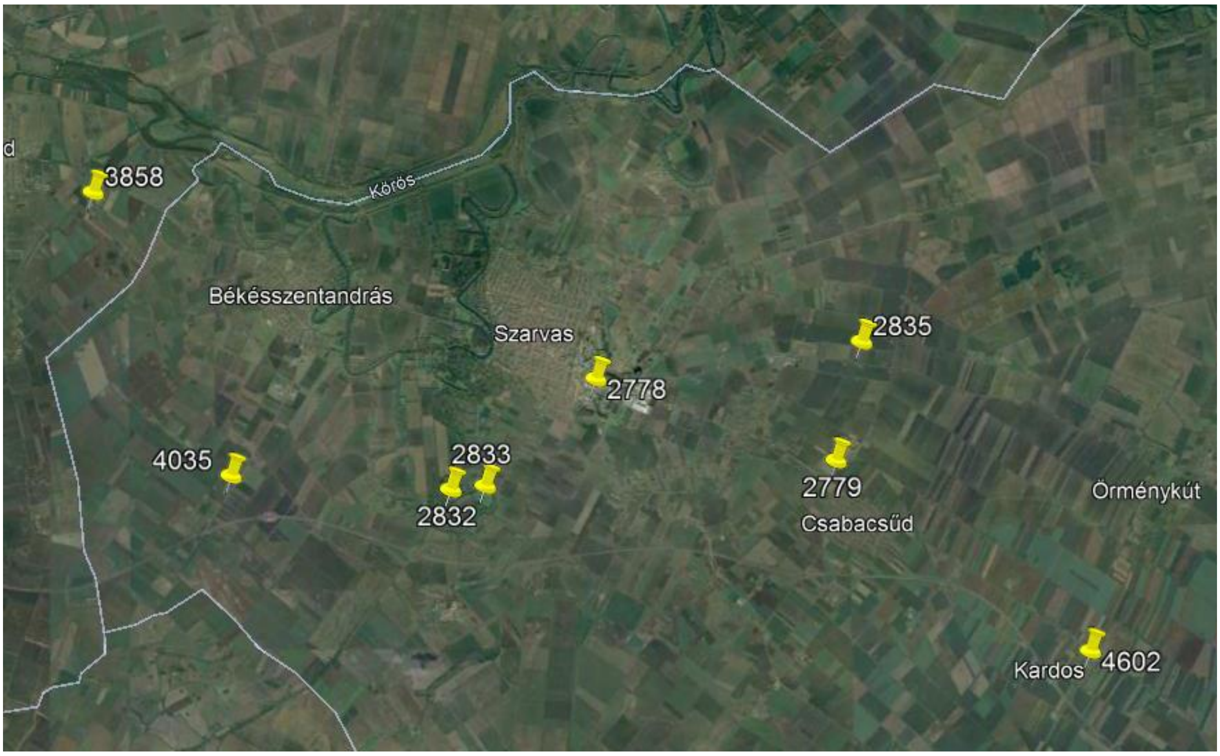

Figure 1. Location of the monitoring wells in the study area.

The climate is continental with average air temperature of 10.8°C and yearly average precipitation of 515 mm. Annual course of precipitation shows a slight maximum from May to July and minimum from January to March (*Table 1.*).

Table 1. Average air temperature (T, °C) and precipitation (P, mm) in Szarvas, 1981-2010.

	1	2	3	4	5	6	7	8	9	10	11	12	year
T	-1.0	0.5	5.6	11.5	16.8	19.8	21.9	21.4	16.6	11.2	5.0	0.3	10.8
P	29	30	28	42	51	61	58	51	48	32	41	45	515

The groundwater level data of 8 monitoring wells were provided by Körös Region Water Directorate. Most data series start in year 2002 and finish in 2020 or 2021. There were changes in the frequency of measurements during this time period. In the first years manual measurements of the groundwater level were carried out weekly. After automatization data were get daily, later in every 4 hours (six times a day). The monitoring stations represent different types of topography and location related to the oxbow (*Table 2.*).

Table 2. Groundwater monitoring stations metadata.

Monitoring well	soil surface elevation	first data	daily data from	data for every 4 hours from	last data for the study
Békésszentandrás (4035)	82.82 m	2002.01.	2014.11.	2014.11.	2021.01.
Csabacsűd (2779)	84.79 m	2002.01.	2004.01.	2006.01.	2021.08.
Kardos ((4602)	85.43 m	2004.11.	2004.12.	2010.06.	2021.11.
Öcsöd (3858)	84.21 m	2002.01.	2004.11.	2005.11.	2021.12.
Szarvas (2778)	83.19 m	2002.01.	2003.12.	2005.12.	2021.12.
Szarvas (2832)	82.02 m	2002.01.	2017.11.	2017.11.	2021.06.
Szarvas (2833)	81.87 m	2003.07.	2010.05.	2010.05.	2021.12.
Szarvas (2835)	84.00 m	2002.01.	2004.01.	2004.03.	2021.12.

Before the statistical examination the monthly average groundwater levels were calculated for each well for the whole period using software Excel. Parallel, the check of missing data was performed.

The average annual groundwater level course of each wells was calculated. It was important to do it based on the same time interval for all of the 8 wells (2005-2020) not to get misleading results. Using the data and graphs it was possible to describe the main characteristics of groundwater level in the study area and identify groups of wells with distinguishable patterns.

The main aim was to find long term trends of groundwater level. The trend analysis was based on 5 time series data set (annual, and middle months of the seasons: January, April, July and October) for groundwater level of 4 monitoring wells. The criteria for choosing this 4 wells were: they represent different groundwater characteristics, their data sets have no interruptions over the period 2002-2020.

The analysis was based on the nonparametric Mann-Kendall test for the significance of trend and the nonparametric Sen's method for the magnitude of the trend. These methods are commonly used in analysing climate time series and groundwater level time series, too. Practically, the MAKESENSE Excel Macro developed by the Finnish Meteorological Institute were used in our research (Salmi et al., 2002).

RESULTS AND DISCUSSION

In average of 16 years the groundwater level (GWL) reaches its maximum in April. It is in accordance with the results of previous studies made in Hungary. The groundwater reaches its deepest level in autumn, but there are differences in months. Both September, October and November can be the month when the GWL reaches its minimum. That is in average, but there were years with maximal GWL in January, February, March, April or in December, and with minimal GWL in any month from July to February (*Figure 2.*)

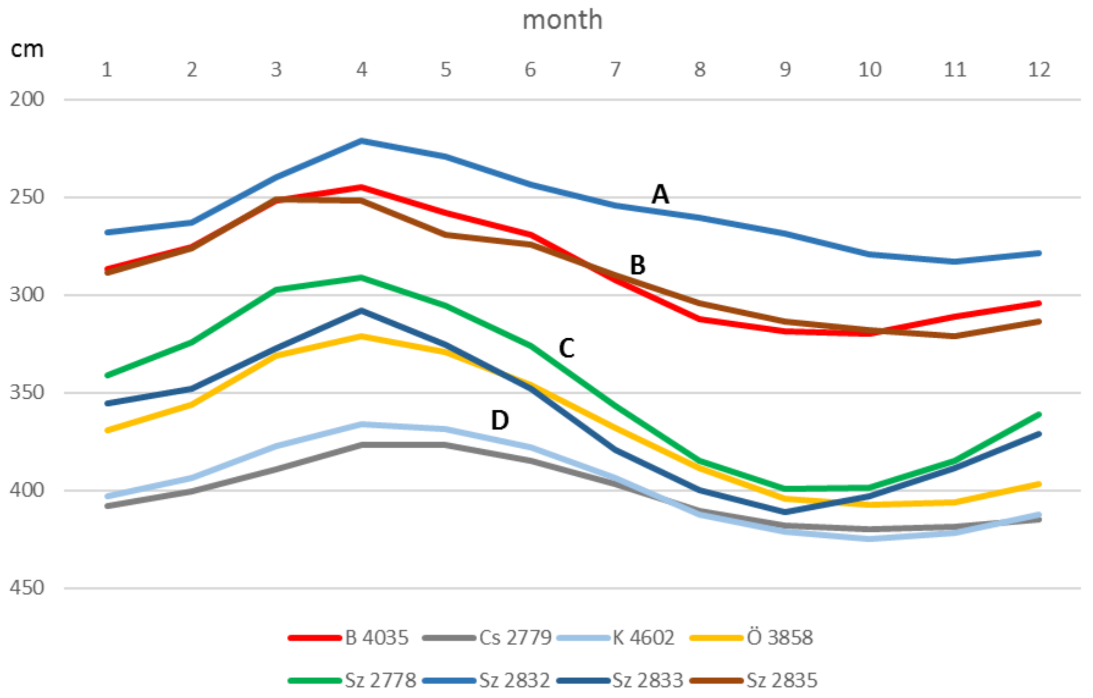

Figure 2. Average annual course (2005-2020) of groundwater level of the monitoring wells. A, B, C, D: groups of groundwater level course.

According to the graphs showing 16-year-average, 4 typical groups of groundwater level courses can be distinguished:

A. Highest groundwater level, small annual variation. Szarvas 2832 (Sz 2832) is the only well with this characteristics. It can be clearly explained by the effect of the nearby oxbow (70 m distance).
B. Relatively high groundwater level in winter and spring, medium annual variation. Békésszentandrás 4035 (B 4035) is located at a low terrain (only stations near to the oxbow have lower elevation above sea level), while Szarvas 2835 (Sz 2835) has a higher elevation, but with a local depression in the topography (about 1 m compared to the surrounding).
C. Medium groundwater level, large annual variation. Monitoring stations Öcsöd 3858 (Ö 3858), Szarvas 2778 (Sz 2778) represent the medium level terrains in our study area.
D. Deepest groundwater level, small annual variation. Csabacsűd 2779 (Cs 2779) and Kardos 4602 (K 4602) represent the loess areas in the eastern part of the study area with elevation about 85-86 m above sea level.

The expressions such as low, medium, high GWL and others describing seasonal variation are only valid in the context of our research.

Near to the oxbow the average GWL is about 2.5 m, while at higher elevated areas it is 4.0 m. The annual amplitude calculated from the average monthly values is small near the oxbow (0.6 m) and at the higher elevated loess areas (0.5 m) with the deepest GWL. It has to be noted that a larger average amplitude is get in case the yearly amplitudes are calculated first and just averaging after that.

Table 3. Average groundwater depth and its annual amplitude (using monthly average data, 2005-2020).

well groups	average (cm)	amplitude (cm)
A	257	62
B	288	72
C	360	100
D	400	51

The long term trends of GWL were studied based on time series of yearly average GWL and the GWL values of January, April, July and October. The trends of yearly average values show the decrease of groundwater level in case of Szarvas 2832, Szarvas 2778 and Békésszentandrás 4035 monitoring wells (*Figure 3.*). These decreasing trends are significant at p= 5% or 1% level (*Table 4.*), with the largest rate of 7.6 cm/year (Q, the Sen's estimator, the groundwater level change per year) in case of the well near the oxbow (Sz 2832). The GWL at Station Cs 2779 (deepest groundwater level, small annual variation) shows no significant trend in groundwater level during the 2002-2020 period.

The decreasing GWL at 3 stations can not be explained by the changes in yearly precipitation sums. The precipitation has no decreasing trend during this period (*Figure 4.*). However, the yearly average air temperature is increasing (significant, 0.78°C/10 years increase). This can be a cause of the groundwater level sink through the indirect effect of temperature on evapotranspiration.

Table 4. Parameters of the linear trend analysis based on data sets (yearly average, January, April, July and October) for groundwater level at 4 monitoring stations (2002-2020).

	Sz 2832			B 4035			Cs 2779			Sz 2778		
	R^2	Q	sign.	R^2	Q	sign.	R^2	Q	sign.	R^2	Q	sign.
year	0.42	-7.6	**	0.18	-4.4	*	0.00	-0.3	-	0.34	-6.4	*
Jan	0.30	-7.3	**	0.07	-4.0	*	0.00	+0.4	-	0.23	-6.9	*
Apr	0.20	-6.8	*	0.11	-5.0	-	0.00	+1.0	-	0.27	-7.2	*
July	0.37	-7.5	**	0.19	-4.2	*	0.00	-0.3	-	0.26	-6.2	*
Oct	0.46	-7.5	*	0.28	-4.3	**	0.01	-1.9	-	0.29	-6.9	*

Mann-Kendall test ** trend at $\alpha = 0.01$ level of significance, * trend at $\alpha = 0.05$ level of significance, – no significant trend, Q, the Sen's estimator, R^2: coefficient of determination calculated by Excel to linear trend.

The year to year GWL variability is larger in January and April compared to July and especially to October. The trends of the middle months of the seasons (January, April, July, October) are almost the same in significance and slope compared to the trends based on yearly mean time series (*Figure 5-8.*). The differences in trends can be found between stations rather than between the months used for calculations.

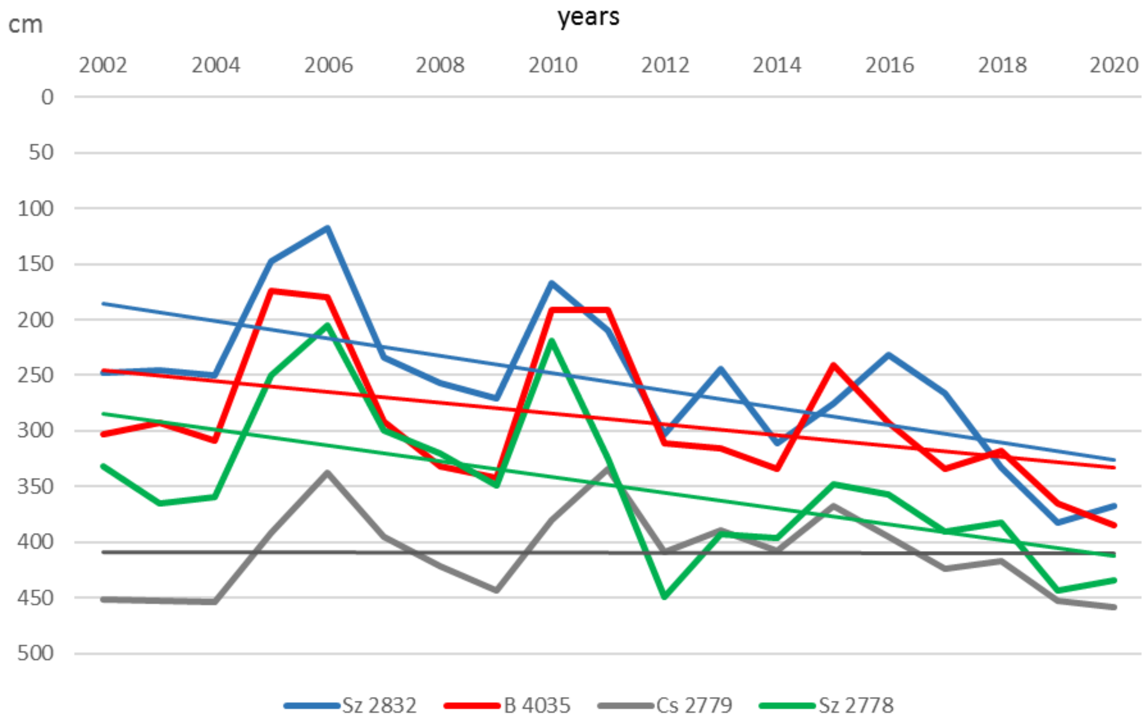

Figure 3. Course of the yearly average groundwater level at 4 monitoring stations (2002-2020).

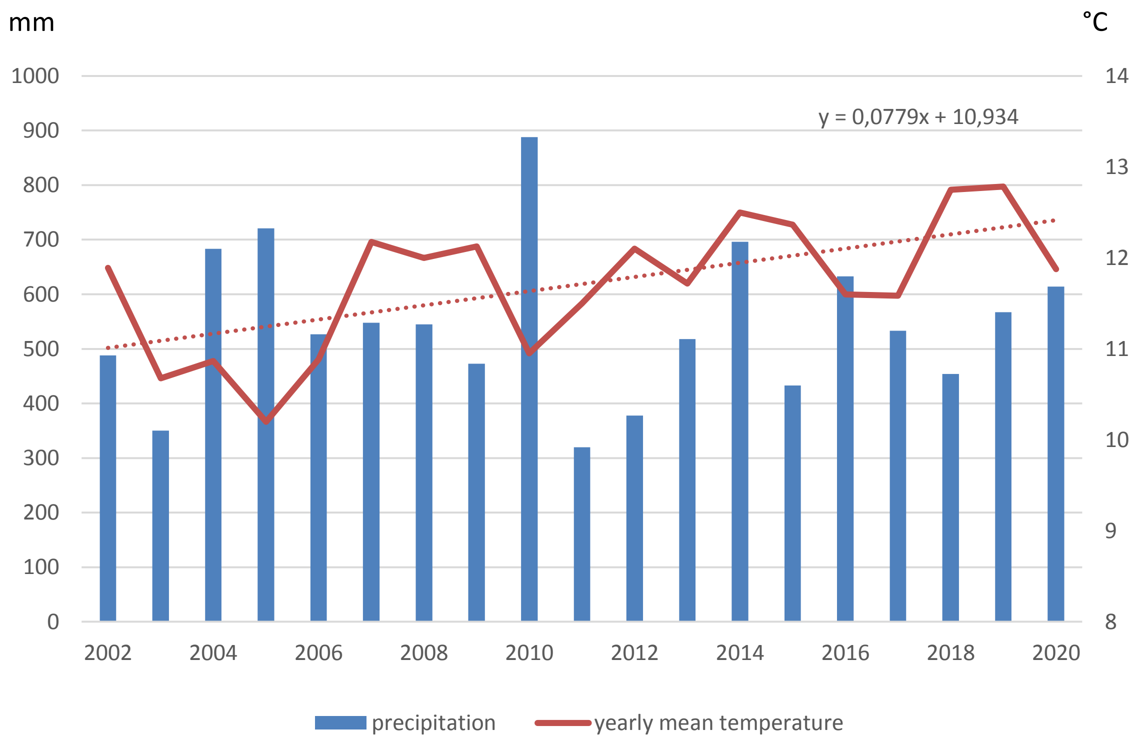

Figure 4. Course of the yearly sum of precipitation (mm) and the yearly mean air temperature in Szarvas (2002-2020).

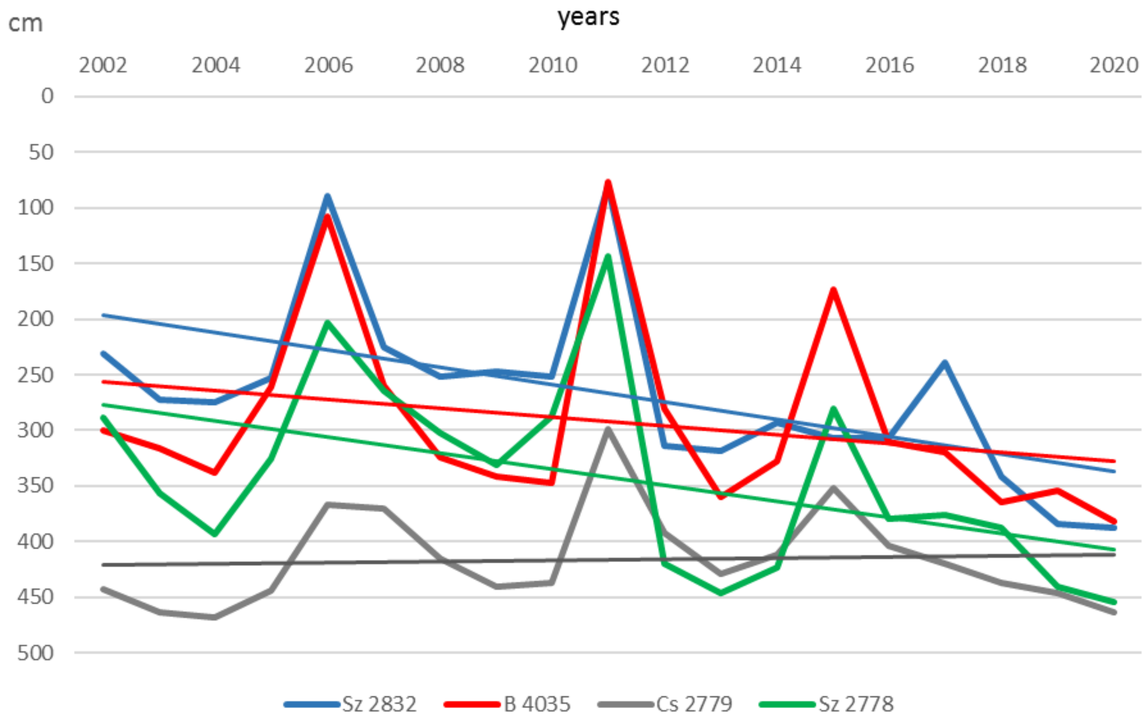

Figure 5. Course of the January mean groundwater level at 4 monitoring stations (2002-2020).

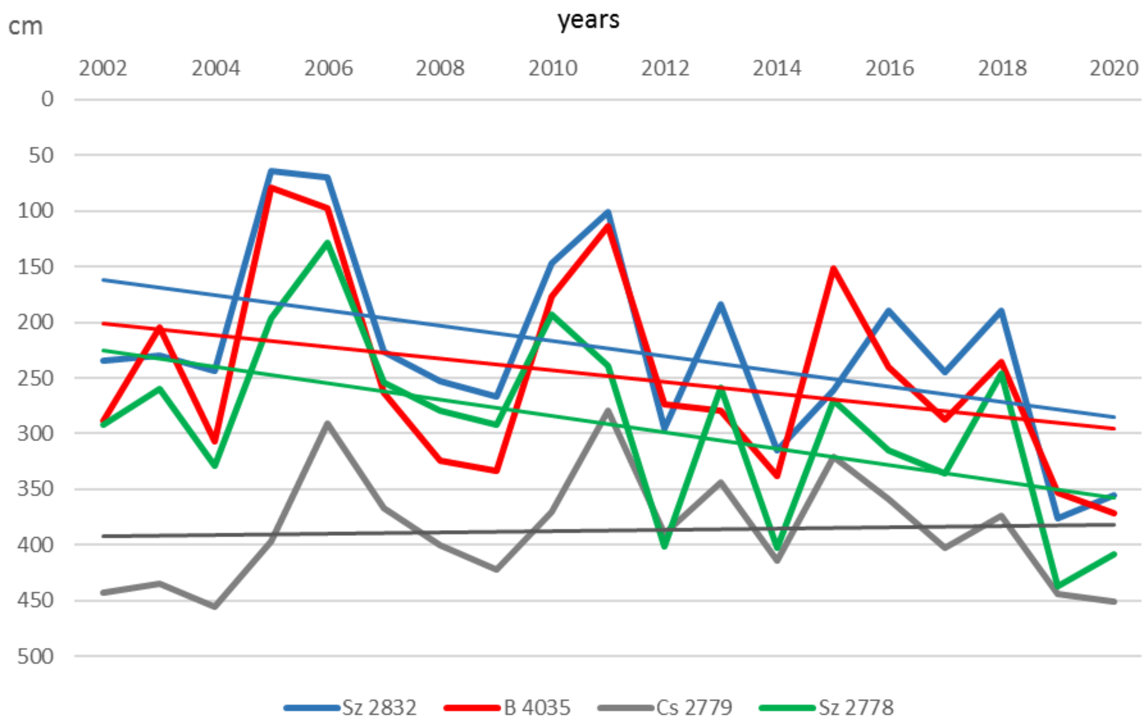

Figure 6. Course of the April mean groundwater level at 4 monitoring stations (2002-2020).

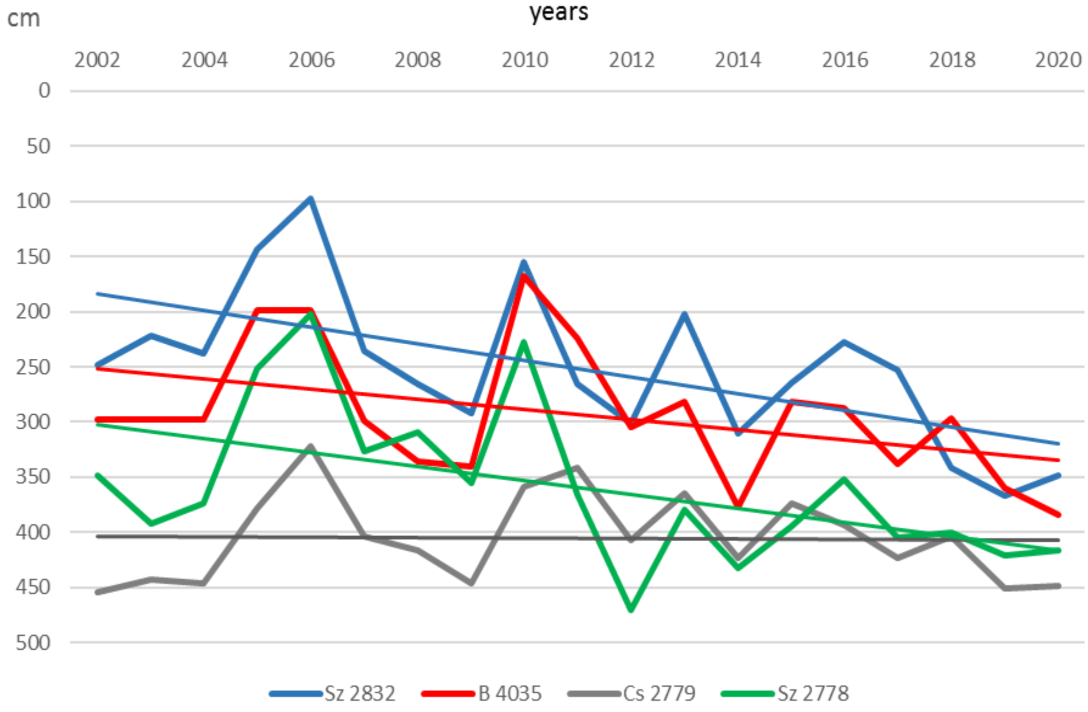

Figure 7. Course of the July mean groundwater level at 4 monitoring stations (2002-2020).

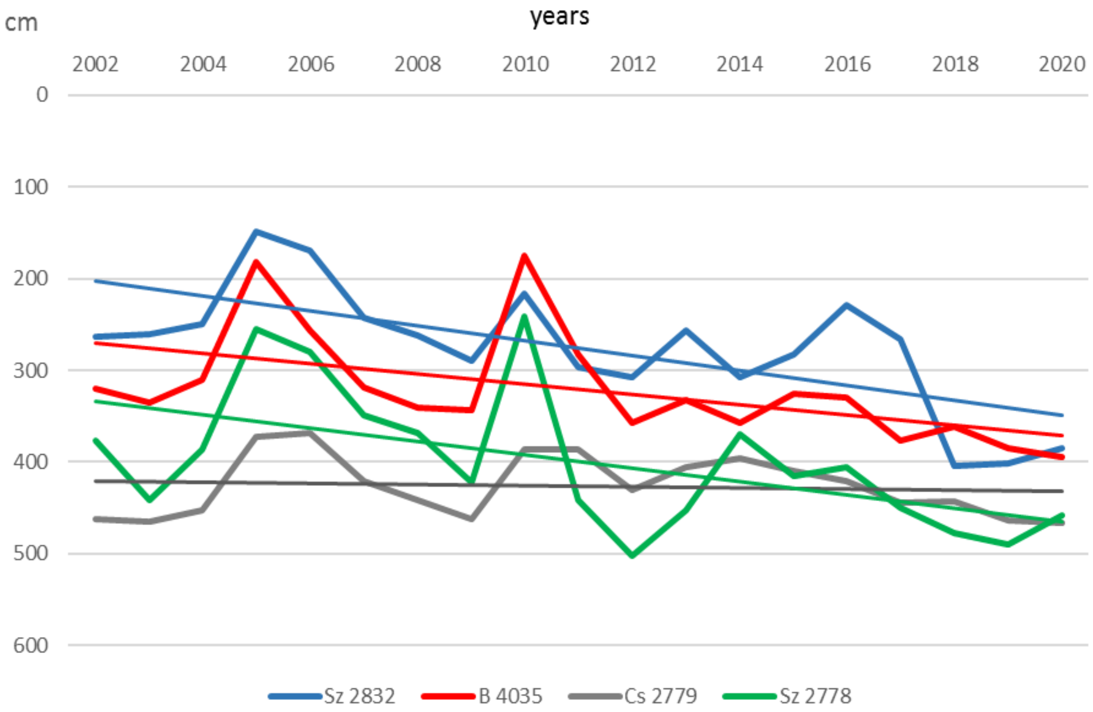

Figure 8. Course of the October mean groundwater level at 4 monitoring stations (2002-2020).

It can be concluded that in the study period (2002-2020) there was a decline in groundwater levels in the Szarvas-Békésszentandrás Oxbow Subbasin in most monitoring wells. The change exceeds 1 m at station Szarvas 2832 (144 cm) and Szarvas 2778 (122 cm). That has an agricultural importance because the recent level of groundwater can much less contribute to the water supply of arable crops than the earlier values. However, there is a station with no significant trend, GWL at Csabacsűd 2779 station shows relative stability at around 4 meter depth in yearly average, which is valid for some areas in the eastern part of the subbasin.

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ANALYSIS OF THE PRECIPITATION LEVEL IN ROMANIA IN THE CONTEXT OF CLIMATE CHANGE AND ITS IMPACT ON AGRICULTURE

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ABSTRACT

All economic sectors are and will be affected by climate change. Agricultural production is largely dependent on weather and climate conditions and is therefore one of the most vulnerable sectors. The recent low rainfall, but especially the uneven repatriation, is influencing crop yields and animal productivity, which in turn are affecting agricultural incomes. The analysis of historical precipitation data and the forecast for the next few years clearly show the production of severe summer droughts in Romania, especially in the southern and south-eastern areas. Used the bivariate Pearson Correlation model the authors find that there is a moderate relationship between the level of precipitation and the average level of cereals obtained in Romania, with a higher correlation for maize and a lower one in the case of wheat.

Keywords: climate change, rainfall, production level, Pearson Correlation model

INTRODUCTION

The impact of climate change is reflected in the increase in global temperature and the decrease in annual rainfall, which negatively affects agricultural productivity and thus the income of this sector (Machili 2020).

Climate change involves reducing greenhouse gas emissions and adapting green systems to the effects of climate variability. In order to have a positive effect, adaptation must be targeted taking into account the priorities of sustainable development. The sixth report of the Intergovernmental Panel on Climate Change (IPCC 2021) states that the average global air temperature has risen by 1.09°C (over the last 150 years), and the decade 2011-2020 was one of the warmest in the data series recorded after 1850. A variable distribution is observed (increase/decrease) in time and space of the annual amount of precipitation. The number of extreme events (long droughts followed by heavy rainfall, floods, tornadoes) is increasing especially in Europe and North America (IPCC 2021).Over 90% of all extreme events in Europe over the last 30 years have been caused by dangerous hydro-meteorological phenomena (floods, storms) (Hofstatter et al. 2017) and climatic (heat waves, droughts, wildfires) (Dumitru et al. 2014). In this context, climate change is a major challenge for the agricultural sector, and ensuring water resources and crop stability are major priorities.

Romania's climate has changed a lot in recent decades. Heat waves last longer, it snows less often and less, and extreme phenomena multiply. 40 years ago it was summer months when temperatures did not exceed + 35°C, and at Christmas it was often cold and heavy snow. Now, there are more and more frost-free days and more and more summer nights with over +20°C. Most cold records are from 60-70 years ago, while many heat records have been broken in the last 15 years. Compared to the annual average temperature of the last century that of the last ten years is on average +1.5°C higher, which is not small at all. At some weather stations the amount of precipitation has increased during the autumn, and the tendency is to decrease the precipitation during the summer (Mateescu 2019).

In order to analyze the impact of climate change on agricultural production, several studies have been conducted, both globally and nationally. Studies show that there is a positive correlation between changing climate variables and the level of agricultural productivity. Parry et al. (Parry et al. 2004) analyzed the global consequences for crop yields, production and the risk of hunger in different socio-economic and climate scenarios. Lobell and Field (Lobell and Field 2007), Lobell et al. (Lobell et al. 2011), found that crop yields are declining due to changing climate variables, such as rainfall and temperature. Allen et al. (Allen et al. 2003) and Thomson et al. (Thomson et al. 2005) concluded that a 1 degree increase in global temperature will result in lower productivity in some cultivated plants, such as 17% in maize and soybeans. Aninagyei and Appiah (Aninagyei and Appiah 2014) also found a correlation between precipitation levels and average annual temperature correlated with annual maize and rice production. Poudel and Shaw (Poudel and Shaw 2016) noted that there is a differential impact of climate change on major crop production in the mountainous parts of Nepal.They concluded that the current climatic conditions greatly affect winter crops. For example, barley production, one of the crops and staple foods in the mountainous region of Nepal, is declining due to rising temperatures and low rainfall. The level of rainfall during the summer, even if the temperatures are higher in the last period, has contributed positively to the yield growth of summer crops. To show the relationship between precipitation variability and crop production in Kupwara District (India) for the period 2001-2015, Batool et al. (Batool et al. 2019) found that there was a positive correlation between annual rainfall and agricultural production in almost all crops, with the exception of almonds, which showed a negative correlation with spring rainfall.

In the literature we find other studies with different observations. Affholder et al. (Affholder et al. 2013) argue that crop yields are influenced primarily by the crop system, and then by climatic conditions. De-Graft and Kyei (De-Graft and Kyei 2012) studied the impact of climate and crop area variables on maize crop productivity in Ghana. Research has shown that there is a positive correlation between average maize yield and area, and a negative correlation between yield and climatic conditions (precipitation, temperature). In addition, they concluded that an increase in crop area and temperature will lead to higher productivity for maize, while an increase in precipitation will decrease the variability of maize yield. Olesen et al. (Olesen et al. 2007) conducted an extensive study, using variance analysis, to simulate the performance (impact) levels of agriculture in the conditions of global climate models and local soil and climate conditions of European ecosystems. Their research showed that the simulated results related to climate models had a smaller variation compared to those attributed to either the emission scenarios or the local conditions. Irimia et al. (Irimia 2018) analysed the impact of climate change on the spatial distribution of climate adequacy for wine production in Romania for a period of 52 years, divided between 1961-1990 and 1991-2013. The impact of climate change on Romanian viticulture generates both beneficial and negative consequences. While expanding the wine-growing area by 2.4 million ha, it has changed the specific climate and traditional wine-type production of today's wine-growing areas. There is also a tendency to change climate suitability on a regional scale by reducing suitability for white wines and replacing it with climate suitability for red wine.

The present article is in the direction of the research presented above with the aim of determining the impact of rainfall on cereal production (and separately on wheat and maize) in Romania, in the period 1990-2019, in the conditions of climate change recorded recently.

MATERIALS AND METHODS

The paper is based on a rich review of the literature in the field and historical data on the level of production and precipitation, collected from statistics and the database of the National Meteorological Administration.

The bivariate Pearson Correlation model was used to examine the strength and direction of the linear relationship between the level of grains production (and separately wheat and maize) obtained over the time horizon 1990-2019 in Romania, and level of the rainfall.

The bivariate Pearson Correlation produces a sample correlation coefficient (*r)*, which measures the strength and direction of linear relationships between pairs of continuous variables (Rujescu 2015; Rujescu et al. 2017). The correlation coefficient can range in value from −1 to +1. For the Pearson correlation, an absolute value of 1 indicates a perfect linear relationship. A correlation close to 0 indicates no linear relationship between the variables.

The results obtained indicate a moderate correlation between the level of precipitation and the average level of cereals obtained in Romania, with a higher correlation for maize and a lower one in the case of wheat.

RESULTS

Precipitation is the main source of water for the growth and development of agricultural crops, and the most significant elements of this meteorological parameter are the quantitative variability and space-time distribution. The optimal and critical limits of the precipitation amounts falling on intervals characteristic of the various phases of growth of agricultural plants are represented in Table 1. This type of quantification establishes the significance of the rainfall regime of each interval in relation to the reference thresholds characteristic of each cultivated species.

In Romania, in the spring months, critical intervals of rainfall over the climatic environments can be observed, which have a negative effect on the plants in the first phases of vegetation. Due to the large amounts of water that fall quickly, the soil is heavily compacted, the water stagnates and the roots of the plants die by suffocation. Storms and hail during the summer months also cause negative effects, partially or completely disrupting the rich vegetation. The use of appropriate agrotechnical measures or the cultivation of drought-resistant varieties or hybrids can lead to good yields even when there are short periods of drought. However, if the drought persists for a long period of time, production decreases significantly or is completely compromised.

Table 1. Optimal and critical limits of precipitation amounts at intervals characteristic for the growth and development of agricultural crops

Interval (months)	Significance of precipitation amounts (mm) - reference thresholds					
	Excessive drought	Dry	Moderately dry	Optimum	Rainy	Excessive rains
IX-X	<40	40-60	61-80	80-120	121-150	> 150
XI-III	<100	101-150	151-200	201-300	301-400	> 400
N	<20	21-30	31-40	41-60	61-80	> 80
V-VI	<50	51-100	101-150	151-200	201-300	> 300
VII VIII	<80	81-100	101-150	151-200	201-300	> 300
V-VIII	<150	151-200	201-300	301-400	401-500	> 500
IV-X	<250	251-350	351-450	451-500	501-600	> 600
IX VIII	<350	351-450	450-600	601-700	701-800	> 800

Legend:
IX-X: sowing-emergence period for autumn cereal crops
XI-III: period of water accumulation in the soil (cold season)
IV: sowing-emergence period for spring cereal crops
V-VI: the period with maximum water requirements for autumn wheat
VII-VIII: period with maximum water requirements for maize
V-VIII: water-critical period of agricultural crops
IV-X: active vegetation season
1 IX (previous year) -31 VIII (current year): agricultural year
Source: Dumitru et al. 2014.

The analysis of historical precipitation data from a number of 17 meteorological stations in Romania, with a consecutive series of measurements over 110 years, highlights the fact that in terms of rainfall there is a tendency to decrease the annual precipitation amounts in the period 1981-2020 with 1901-1980, situation reflected in Table 2.

*Table 2.*The level of average annual rainfall in Romania, 1981-2020 vs. 1901-1980

Period	Average multiannual precipitation (mm)	Trend
1901-1980	638.2	-1.9%
1981-2020	626.0	

Source: Adapted from Dumitru et al. 2014; National Meteorological Administration 2020.

From 1901 until today, every decade there have been 1-2 to 3-4 years of extreme drought or rain. The highest number of dry years was in the decade 2001-2010 (5 years), and the warmest years were in the decade 2011-2020 (2019, 2020, 2028 and 2012). In fact, the last decade has been characterized by the highest level of average annual temperatures. There has also been an increasing frequency in recent years of periods of heavy rainfall over short periods of time (eg spring and summer 2006, summer 2008 and 2010, spring and autumn 2013, spring and summer 2014). The alternation of dry periods followed by rainy intervals is more and more present in recent years.

The analysis of the multiannual average values of precipitation at regional level shows a decrease in quantities, especially in southern and eastern Romania reflecting a dry rainfall regime (in the south) and moderate dry rainfall (in the east) (Dumitru et al. 2014). In the agricultural year 2019-2020, during the period of maximum water consumption of weeds (June, July and August), the recorded precipitations were deficient (≤200 l/sqm) in Dobrogea, on large areas of Oltenia, Muntenia (southern Romania) and Moldova (eastern part of Romania), where soil moisture deficits were maintained, the phenomenon of pedological drought having different degrees of intensity, respectively moderate, strong and extreme (National Meteorological Administration 2020).

To analyse the influence of average annual rainfall on average cereal yield, the authors used the 1990-2019 historical data series (Figure 1). The correlation was demonstrated using the Pearson coefficient, which indicates a value of 0.283, which means a moderate correlation between the two variables (Table 3).

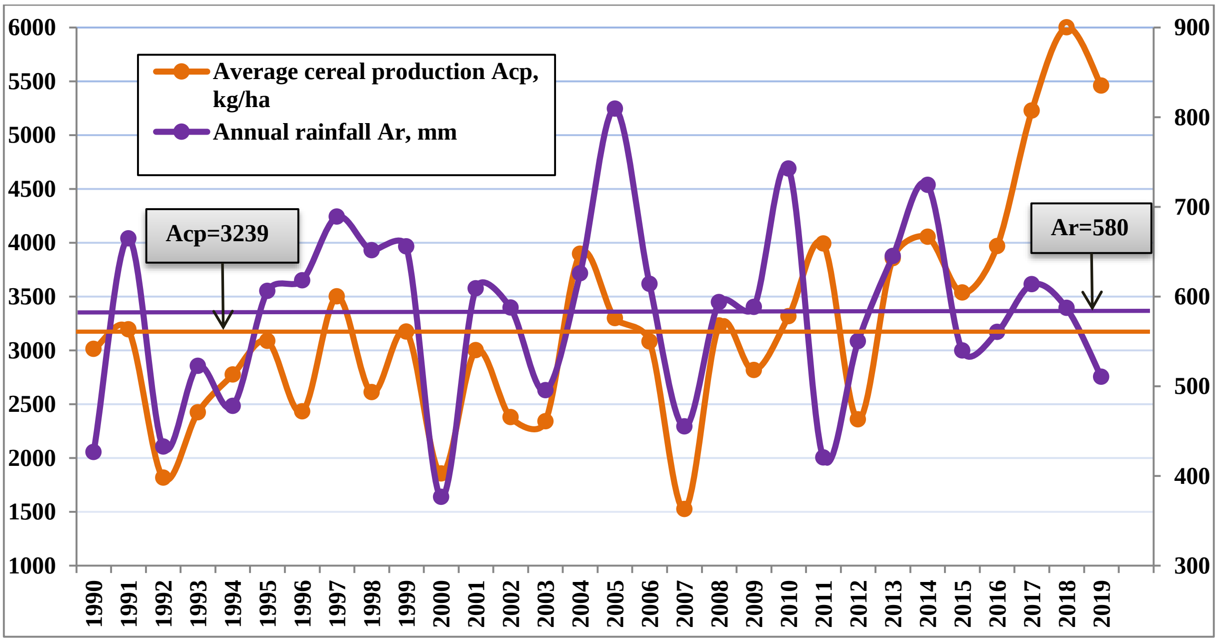

Figure 1. Average cereal production (kg/ha) and annual rainfall (mm) in Romania – historical data

Table 3. Pearson correlation coefficients

		Average Production	Annual average rainfall
Average Production	Pearson Correlation	1	0.283
	Sig. (2-tailed)		0.130
	N	30	30
Annual average rainfall	Pearson Correlation	0.283	1
	Sig. (2-tailed)	0.130	
	N	30	30

Source: Authors' calculation with the use of the SPSS statistical software

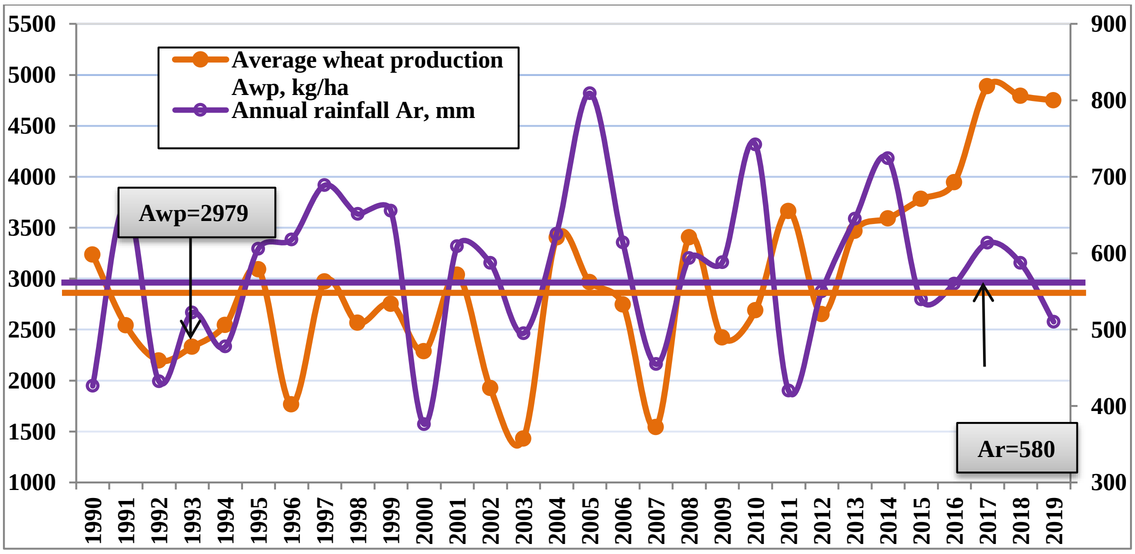

Figure 2. Average wheat production (kg/ha) and annual rainfall (mm) in Romania – historical data

Table 4. Pearson correlation coefficients

		Average wheat yield	Annual average rainfall
Average wheat yield	Pearson Correlation	1	0.139
	Sig. (2-tailed)		0.465
	N	30	30
Annual average rainfall	Pearson Correlation	0.139	1
	Sig. (2-tailed)	0.465	
	N	30	30

Source: Authors' calculation with the use of the SPSS statistical software

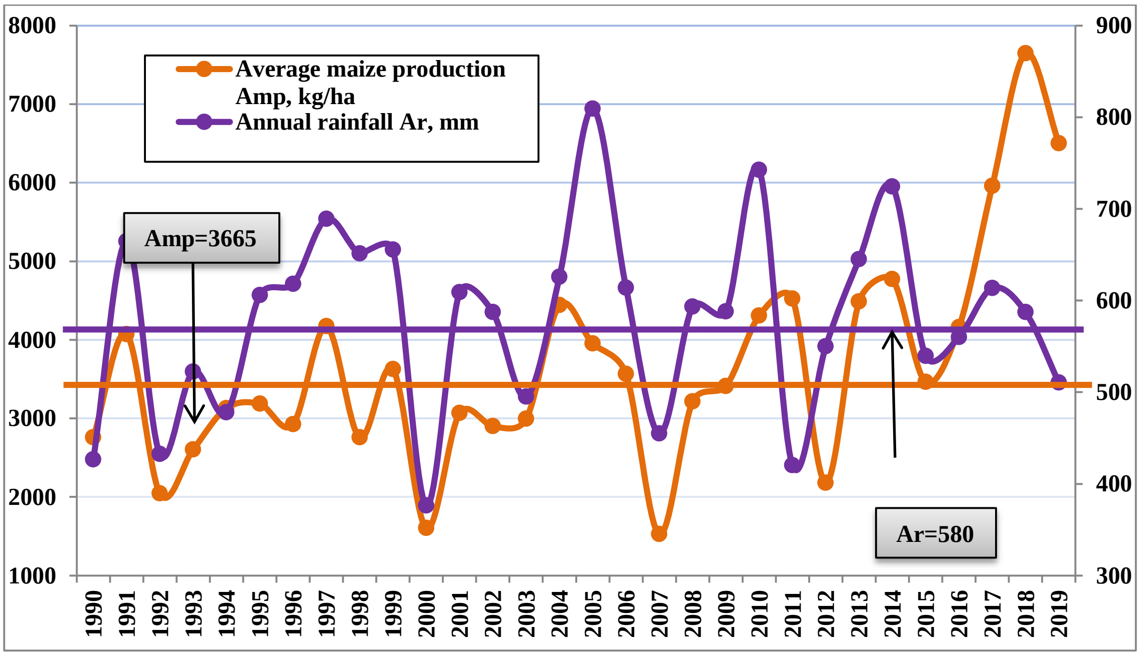

Figure 3. Average maize production (kg/ha) and annual rainfall (mm) in Romania – historical data

Table 5. Pearson correlation coefficients

		Average maize yield	Annual average rainfall
Average maize yield	Pearson Correlation	1	0.358
	Sig. (2-tailed)		0.052
	N	30	30
Annual average rainfall	Pearson Correlation	0.358	1
	Sig. (2-tailed)	0.052	
	N	30	30

Source: Authors' calculation with the use of the SPSS statistical software.

DISCUSSION

This article has examined the tendency of annual rainfall and association between precipitation level and crop production. For analysing the trend in annual rainfall data series, with a length of 119 years, i.e. 1901 to 2020, was used. Romania observes decreasing trend of annual rainfall, from 638.2 mm on average in the years 1901-1980, to 626 mm in 1981-2020 (decreasing by 1.9%).

To show the relationship between the precipitation variability and cereal production (and wheat and maize separately) in Romania for the period 1990-2019, data used include the average annual yield and the average annual precipitation level. There is a moderate relationship between the level of precipitation and the average level of cereals obtained in Romania, with a higher correlation for maize and a lower one in the case of wheat. The authors wondered if this correlation affected in any way the Romanian cropping pattern (Table 6).

Table 6. Variation in cropping pattern in Romania

	1990-2000		**2001-2010**		**2011-2020**	
	thousand ha	**% of cultivated area**	**thousand ha**	**% of cultivated area**	**thousand ha**	**% of cultivated area**
Cultivated agricultural area	9,002.2	100.0	8,293.4	100.0	8,310.3	100.0
Area cultivated with cereals	6,003.0	66.7	5,578.3	67.3	5,385.2	64.8
Area cultivated with wheat	2,078.9	23.1	2,176.0	26.2	2,088.9	25.1
Area cultivated with maize	3,003.9	33.4	2,689.4	32.4	2,561.8	30.8

Source: Developed by the authors based on Tempo online databases (AGR108A).

The authors concluded that the changing rainfall affect the cropping pattern in Romania. Crops that require more rainfall are affected due to declining rainfall during their growing period, which causes farmers to move to those crops that need less rainfall, which leads to a change in cropping pattern.The variation in rainfall has resulted into change in area under maize, where the decreasing tendency of the cultivated area is the most accentuated. For this culture, the Pearson correlation coefficient had a higher value (0.358), which means that the level of precipitation affects to a greater extent the productivity of this crop.

The area cultivated with wheat in Romania increased in the decade 2001-2010 compared to the previous one, but currently the area cultivated with wheat is slightly decreasing.The use of appropriate agrotechnical measures or the cultivation of drought-resistant varieties or hybrids can lead to good yields even when there are short periods of drought. However, if the drought persists for a long period of time, production decreases significantly or is completely compromised.

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WATER IN FOOD – THE METHODS OF QUANTITATIVE DETERMINATION A REVIEW

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ABSTRACT

Water is essential for life and it plays an essential role in the physical and chemical functions of our body, the food we consume, and the materials around us. The determination of the humidity constitutes one of the essential methods used in the control of the food. This method gives information regarding the nourishing value, the perishability, the value of his digestive use, as well as information about its technological efficiency. The humidity is checked for all the foodstuff, either directly valuing the quality of water, or indirectly by measuring the dry substance remaining after the removal of water. The water content is also important for the processing and handling of the following categories of products: cosmetics, pharmaceuticals, food, personal care in the pulp and paper industry, etc. The purpose of this study was to highlight and compare the different types of analyses used in the quantitative determination of water in various foods. The determination of water from various products can be done by physical or chemical methods, and by direct or indirect methods. Measuring the amount of water contained in certain materials can be very difficult due to the complexity of the water molecule and its strong intermolecular binding capabilities. In most cases, the measurement of water is better defined as the measurement of moisture content.

Keywords: moisture, direct and indirect method, drying, water, Karl Fisher

INTRODUCTION

Humidity assessment is one of the fundamental methods employed in food control. It provides information regarding the nutritional value, perishability, digestive utilization coefficient of a certain ailment, as well as information concerning the technological capacity etc. Both humidity (moisture) and its reciprocal – dry matter – are evaluated for all the aliments. However, it is generally accepted that the term „moisture" includes the summation of all the volatile substances that are simultaneously removed in the same conditions as water (Kirk 1991, Park 1996, Isengard 2001, Gergen 2004, Margolis 2019, Popescu 2019). Although there is a general course of action in this type of work, each product category displays certain distinctive features - albeit nonessential- in regard to the work process.

Water directly influences the quality of products by both in quantity content and condition in products. In food products, water is found in the free state and in the bonding (connected) state (Park 1996, Bulgac 2006, Pop 2010, Sahin 2020). In the processing and testing of food products, moisture determination is an important and most widely used analytical measurement (Bouraoni 1993, Pomeranz 1994, Isengard 2001, Popescu 2019).

Numerous analysis methods are used in lab determinations, methods which differ from one another in applicability and value. The following sections will offer a presentation of various methods employed for water determination, as well as their applicability, providing examples for each method.

WATER. WATER IN FOOD

Quantitatively, water is the main component of natural (unprocessed) animal products.
The human body processes a large amount of food in the process of exchanging substances. The type (nature) of the substances which make up in the composition of the products is very different, as is their proportion (Gergen 2004, Ciumac 2022). The classification of food products is based on the predominance of a certain group of chemicals (Popescu 2019): foods with a protidic predominance (milk and dairy products, eggs, meat, fish and their processing products), foods with a predominance of lipids (food fats), with a predominance of carbohydrates (cereals and derivatives, legumes, vegetables and fruits, sugar and sugar products).

The water content is an indicator of the quality of food, representing a criterion of stability. In standards or other quality norms related to foodstuffs the water content is specified as a percentage (Nielsen 2010, Popescu 2019, Ciumac 2022) in the form of moisture (direct expression), as the maximum limit (max.%), or by the total amount of dry matter in the product (indirect expression), all as a percentage, as the minimum limit (% min.).

The control of the quantity of water contained and its quality allows the evaluation of certain quality characteristics of agri-food products, the degree of freshness (for meat, eggs, fish, fruits, vegetables, etc.), identification of counterfeits (milk, wine, brandy, natural juices, meat minced meat, etc.), manufacture of different varieties in the same type of product (cheese, brandy, etc.), prevention of degradation or alteration (cereals, semolina, sugar, tobacco, black tea), identification of optimal methods of packaging, storage and storage for different types of products, improving their quality through various methods of lowering the water content.

MOISTURE DETERMINATION METHODS IN FOODSTUFFS

The amount of moisture is a measure of stability and quality of food products, yield and quantity of food solids, and is frequently an index of economic value.

An ideal method for analyzing moisture should (Kirk 1991, Park 1996, Nielsen 2010, Margolis 2019): (1) be rapid, (2) be applicable to the broadest range of materials, (3) be performable by any, preferably nontechnical, person with brief training, (4) use readily available apparatus of low initial investment and low cost per test, (5) have reasonable accuracy and good precision, and (6) present no operational hazards.

Numerous authors have reviewed the humidity determination procedures. Generally, the analytical methods are selected for either speed or precision, although both these objectives are concurrently searched for. The determination of water content and dry matter in foodstuffs is an extremely valuable process, because it allows (Gergen 2004, Yazgan 2006, Ciumac 2022):

- the evaluation of the nutritive value in food products;
- the evaluation of prolonged storage options and of preservation possibilities for such products;
- the determination of the freshness or deterioration level for certain products;
- the control of the conformity with the recipe in food production;
- the identification of deceptive practices such as misrepresentation of certain ingredients quantity - the unallowed increase of water quantity etc.

The water content of these products is expressed as a percentage (%) and is a factor that influences their properties, consistency and stability, and is a quality characteristic of first importance.

Analytical methods of moisture determination can be classified in two ways as shown below, in Table 1 and 2. (Park 1996, Kirk 1991, Nielsen 2010, Margolis 2019). One way of classifying the methods (see table 1) is based on analytical principles, and consequently there are methods based on sample drying (drying methods), methods based on distillation (distillation methods), physical methods and chemical methods. The other classification manner depends on underlying scientific theory – direct and indirect procedures.

Table 1. Classification of analytical methods for moisture determination by major principles (Park 1996)

	Principle type	Method
1.	Drying method	oven drying vacuum drying freeze-drying chemical desiccation
2.	Distillation Method	Azeotropic distillation
3.	Chemical Methods	Karl Fischer titration Generation of Acetylene Heat on mixing with H_2SO_4
4.	Physical Methods	Infrared Absorption Near Infrared Reflectance Gas chromatography Nuclear Magnetic Resonance Refractometer Neutron Scattering Electrical Microwave absorption Dielectric capacitance Conductivity

In direct methods, moisture is normally removed from the solid food samples by drying, distillation, etc., and its quantity is measured by weighing, titration, and others (Kirk 1991, Park 1996, Isengard 2001, Gergen 2004, Margolis 2019, Popescu 2019). Instead, in indirect methods, water (moisture/humidity) is not removed from the sample, but properties of the wet solid which depend on the amount of water or number of hydrogen atoms are measured (Park 1996, Isengard 2001).

The indirect methods which are carried out must be calibrated against the standard humidity values that have been accurately determined by using one or more direct methods. As a result, the values of the direct measurements used for calibration determine the accuracy of the indirect methods.

In general, the results of direct methods consist in precise and even absolute values as regards the moisture assessment (Park 1996, Isengard 2001, Pop 2010, Margolis 2019). However, these methods are predominantly manual and take up a great deal of time. Conversely, indirect techniques show speed, they cause no destruction of the investigated material and they provide the possibility of continuous determination through automation.

As it is more suitable for the presentation, the moisture assessment procedures are divided into two categories: direct and indirect ones.

Table 2. Classification of analytical methods for moisture determination by direct/indirect procedures (Park 1996)

	Procedure type	**Method**
1.	Direct methods	• Gravimetric methods

		- oven drying - Air oven - Vacuum oven - Freeze drying • Thermogravimetric analysis • Chemical desiccation • Distillation Method • Chemical Titration Method (Karl Fischer) • Extraction Methods • Gas chromatography • Refractometry
2.	Indirect methods	Spectroscopic methods Infrared Absorption Near Infrared Reflectance Spects NMR (Nuclear Magnetic Resonance) Gas chromatography Electrical - Electronic Methods Microwave absorption DC and AC conductivity Dielectric capacitance Sonic and Ultrasonic method Neutron and γ-ray Scattering

DIRECT METHODS

In direct methods, moisture is normally removed from the solid food samples by drying, distillation, etc., and its quantity is measured by weighing, titration, and others (Park 1996, Popescu 2019). The direct method classification is shown in Table 2.

Thermal methods

Thermal methods are based on mass loss by heating the sample, through the process of drying them to constant mass. Known thermal methods are air-oven drying method, vacuum oven drying, freeze-drying and infrared drying technique (Isengard 2003a,b). In this type of procedure, it can be included thermogravimetric analysis (TGA).

a. Air-oven drying method

Drying methods are based on the elimination of water out of products (not only food products) through the process of drying them to constant mass. These techniques consist of the determination of dry matter content in the sample, followed by the calculation of the sample moisture. (Park 1996, Popescu 2019)

The mass loss recorded for 100 g of product is the moisture that is the evaporated water quantity. The oven drying method us considered the most accurate one and is employed for most of alimentary products. (Bulag 2006, Pop 2010, Ciumac 2022)

Due to the fact that it is a convenient procedure, the air-oven drying method is the most frequent choice for standard laboratories all over the world when routine moisture assessments are needed. It can be carried out either with convection-type ovens or with forced-draft ovens.

Modern drying ovens, whose heat is customarily produced either electrically or by infrared heaters, can provide routine and rapid analysis of all stable solid materials.

Since the underlying mechanism of oven drying involves mass loss, the thermal stability of the sample is necessary and also it is important that no significant amounts of volatile compounds are present in the sample (Kiranoudis 1993, Isengard 1995, Park 1996, Ducat 2015, Margolis 2019).

The general steps taken during the process of conventional method for humidity determination by employing the dry oven and analytical balance, are the preparation of the sample, weight measurement, drying, cooling and again measuring the weight. (AOAC, 1990, Park 1996, Heinze 2001, Ducat 2015, Margolis 2019, Popescu 2019).

Calculations:

$$U_{\%} = \frac{m_{lw}}{m} \cdot 100 \qquad (1)$$

$$\%\,solids = 100 - U_{\%} \qquad (2)$$

where, $U_{\%}$ =% moisture,

m_{lw} = loss in weight ,

m = mass (weight) of the sample taken for analysis,

% solids = % mass (weight) of the dry sample (after drying).

Any particular drying technique employed for moisture assessment is affected by a multitude of factors. Variations in samples weight measurement, oven conditions, drying circumstances and post-drying treatments are agents that may trigger certain erroneous results in moisture assessment by oven drying. The stage of sample weighing is affected by the duration of weighing, the absorption of atmospheric vapour, spillage and balance precision.

On the one hand, temperature, pressure, air velocity and relative humidity influence oven conditions, and on the other hand drying conditions are affected by aspects such as: type and location of heating element, shape of container for samples, size of sample container, scorching, drying period, loss of volatile constituents and decomposition (Tomassetti 1989, Ruckord 2001, Yazgan 2006, Popescu 2019).

b. Vacuum Oven Drying

For the majority of alimentary products, the most common and most precise procedure of moisture determination is vacuum-oven drying. This method can overcome some of the disadvantages of the air-oven drying method, since it involves the heating of volatile organic materials at lower temperatures (60-70°C). Obtaining an absolute moisture level by using drying methods is impossible, but nevertheless measuring the moisture level by drying in a vacuum can closely estimate the real moisture content (Park 1996, Isengard 2006).

Calculations are made using the same equation as the air-drying method (see eq. (1) and (2)).

Azeotropic Distillation Method

These methods are fast, however they are less accurate than the drying methods.

The mechanism of this method relies on the separation of water in the sample through a process of azeotropic distillation, by using a liquid which is immiscible with water and lighter than water (benzene, toluene, xylene or any other liquid meeting the following requirements (Bulgac 2006, Pop 2010, Margolis 2019, Popescu 2019, Ciumac 2022): to be lighter than water (density below $1 g/cm^3$), vaporization temperature higher than 100^0 C, thus allowing the separation of water in the inferior part of the collector. The distillation is carried out by using a Dean-Stark apparatus.

This technique is employed for products with a higher water content (vegetable, fruit, cheese, meat and meat products etc). The heat transfer occurs effectively during distillation with a boiling liquid; thus the water is distilled at a fast rate and the oxidation risk is minimized due to the fact that the measurement is made in an inert atmosphere.

Figure 1 shows the Dean-Stark apparatus used for azeotropic distillation. This device has the following constituent parts (Bulgac 2006, Pop 2010, Ciumac 2022.): a heating source under the flask, a 250- or 500 mL round-bottom boiling flask, a Bidwell-Sterling receiver, and a condenser, which simultaneously determines water, fat and residue in a food sample.

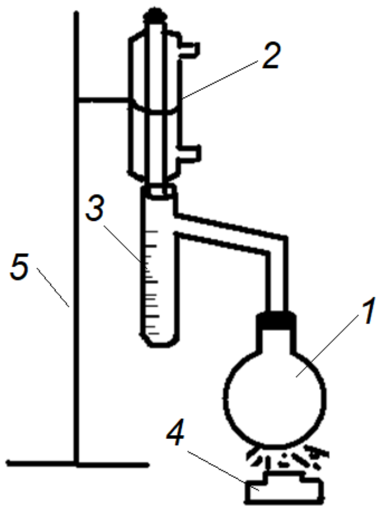

Figure 1. Dean and Stark distillation apparatus for azeotropic distillation

Notes: 1 – round-bottom boiling flask; 2 – condenser; 3 –the graduated test tube collectors (the flask); 4 – heating source; 5 – tripod

Calculations:

$$\%\ \text{moisture} = \frac{\text{loss in weight}}{\text{weight in sample}} \cdot 100$$

The azeotropic distillation lab data have constantly come very near to the value of the theoretical water content, to within 0.1. This value is the normal magnitude of error for the distillation method measurement. Humidity assesement by azeotropic method may encounter certain difficulties, but nevertheless it is a procedure with numerous benefits in contrast with the other direct methods.

Karl Fischer Chemical Method

The Karl Fischer titration method has become regularly and widely used when measuring moisture in solids and liquids (Isengard 1995, Park 1996, Grunke 2000). Its selectivity, high precision and speed (Park 1996, Corpas 2014) are qualities that make it the preferred option for the absolute determination of water. It is especially suitable for types of foods in whose case methods of heat and vacuum application obtain erratic results.

Also, it has been the method of choice for water determination in foods with low humidity levels, such as tea, spices, oil, fats, malt extract, margarine, molasses, cocoa powder and wheat flour. Moreover, this technique particularly shows superiority in moisture measurements for sugar-rich foods or foods rich both in proteins and in reducing sugars (Park 1996, Schmitt 1998, Isengard 2003, 2006, Felgner 2008, Kastens 2008a,b).

Nonetheless, Karl Fischer method is rarely carried out for water determination in foods with a high level of moisture and a heterogenous structure, such as fresh fruits and vegetables. This titration method is supported by the reaction demonstrated by Bunsen in 1853, a reaction which proves the reduction of iodine by sulfur dioxide in the presence of water (Park 1996):

$$2H_2O + SO_2 + I_2 = H_2SO_4 + 2HI$$

Karl Fischer (in 1930) citade by Park (Park 1996) (made changes to this procedure and set up the new quantitating conditions. The constituents of the titration re-agent are iodine, pyridine, and sulfur dioxide in methanol solution.
Calculation:

$$w_s = \frac{0.4 \cdot F \cdot (V_{rs} - V_{r0})}{m_s}$$

where, ws = % water of sample,

V_{rs} = volume of reagent used for sample (ml),

V_{r0} = volume of reagent used for blank (ml),

m_s = weight of sample (g),

F = Standardization factor of reagent (mg water//ml).

INDIRECT METHODS

In indirect methods, water (moisture/humidity) is not removed from the sample, but properties of the wet solid which depend on the amount of water or number of hydrogen atoms are measured (Park 1996).

Infrared Absorption Spectroscopy

The infrared spectrum (known as its fingerprint) of a chemical compound IS one the most characteristic physical property of that compound, which is known as its fingerprint (Park 1996, Isengard 1999). The infrared absorption spectroscopy is one of the most ablest methods of measuring the moisture content (for a large number of solid, liquid or gaseous substances by using suitable wavelengths at which maximum absorption is expected to occur.

Infrared (IR) analysis of fluid milk is based on the ability of the carbonyl groups to absorb IR energy at specific wavelengths, from the ester bonds of fat molecules (5,723 µm), through peptide bonds between the amino acids of protein molecules (6,465 µm) and through OH groups in lactose molecules (9,610 µm) (Isengard 1999, Büning-Pfaue 2003).

The spectral region, between 0.7 and 2.4 µm, for water, has been investigated for measurement of the moisture content in cereal grains. The determination of moisture content can be achieved by comparison of the depth of the band of interest with the same band of standard water concentrations.

Microwave Absorption Method

The principle of this microwave absorption method is based on the property that the molecule of dipole water absorbs several thousand times more microwave energy than a similar volume of any perfectly dry substance (Bouraoui 1993). The property of the water molecule to absorb microwave energy is based on the relaxation of the electric dipole of water in the centimeter wavelength and makes it sustainable for the non-destructive determination of the water content in samples (Park 1996).

Sonic and Ultrasonic Absorption

The sonic and ultrasonic absorption also depends on the amount of water present in the sample. Based on this principle, ultrasonic velocity measurements were used to determine bound water in aqueous electrolyte and non-electrolyte solutions (Kraszewski 1991, Park 1996, Kestens 2008a, b).

Nuclear Magnetic Resonance (NMR) Spectroscopy

The NMR spectroscopy was discovered in 1946 and is a non-destructive method of moisture determination. This method is based on the nuclear properties of hydrogen atoms in water rather than on the properties of the water molecule itself (Park 1996, Tommisetti 1986, 1987, 1989).

The NMR method have been applied to the determination of moisture in virtually unlimited types of foods, including wheat flour, corn, rice, candy, sugar, starch and its derivatives, cheeses and many others.

CONCLUSION

Water is an important component of food products of vegetable and animal origin. It is found in very variable proportions (from 0.1÷ over 95%) in all foods. Water directly influences the quality of products, both in quantity, condition and state. In food, water is free and bound. The water content (respectively in the dry matter - by difference) is an indicator of quality, especially for products where the correction of humidity to optimal values is possible and necessary (e.g. cereals, cheeses, meat preparations, sugary products, etc.).

In direct methods, moisture is normally removed from the solid food samples by drying, distillation, etc., and its quantity is measured by weighing, titration, and others.

The results of direct methods consist in precise and even absolute values as regards the moisture assessment. However, these methods are predominantly manual and take up a great deal of time.

Indirect techniques show speed, they cause no destruction of the investigated material and they provide the possibility of continuous determination through automation. The values of the direct measurements used for calibration determine the accuracy of the indirect methods.

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REFERENCES REGARDING THE INFLUENCE OF THE LAND RECLAMATION WORKS ON THE LOW FIELD OF DENTA VILLAGE IN THE CLIMATE CHANGE CONTEXT

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ABSTRACT

Land reclamation works represents the main anthropogenic kind of issues that made possible a good quality life and provided good premises for agricultural crops in wide areas in Romanian West Field. Between soil characteristics and main cultivated or spontaneous species, it can be establishrelationships of a diverse and complex reciprocity. The soil characteristics can influence the developmentof the root system, mineral nutrition, providing aero-hydric and thermal regime needed to carry the mainphysiological processes and the plants can influence directly and indirectly the state of soil fertility.This paper has as a central point an earlier study that was made a couple years ago in low field of Denta village and regards mainly the soil aspects and changes affected by the land reclamation works and more recently by the last decade climate changes. Also, this paper don't wants to be a conclusion but propose itself to be just one of the first few steps that are made to argue a future and a wider study for rehabilitation and modernization of the main land reclamation works from western part of Romania in the actual climate change context. The climate change trends are summarized but detailed presented, first being with the natural causes (climatic and edaphic conditions in terms of risk phenomena) and then the anthropic causes (deforestation, ,inappropriate agricultural practices, industrial pollution). There are proposed some measures to control land degradation and to increase the economic efficiency of the agricultural cropping.

Keywords: soil, land reclamation, climate change

INTRODUCTION

Environment represented by water, air, soil, vegetation and fauna is a set of spatial temporal formations that function as cybernetic systems, realizing permanent exchange of substances, energy and information, which have the potential to transform cosmic energy into potential energy which stores in plant and animal biomass. In these systems, the soil is essential because it provides food and participate in cycles of ecosystems, being the cradle and source of existence of mankind.

Land reclamation works have a special role in the country's economy, correcting and completing nature and supporting the achievement of large and safe agricultural productions.

This desideratum is achieved by completing the necessary water in the soil in the years and in the dry periods, by eliminating the excess water in the rainy years, by preserving the fertile layer on the sloping lands and by improving the soil fertility.

The purpose of these measures is the basis for maintaining and raising the productive potential of the soil.

The role and importance of hydro-ameliorative works are highlighted by the individual application of irrigation and dewatering-drainage as well as by their simultaneous realization. Land improvement facilities related to the control of soil erosion are subject to hilly areas and are prone to surface or deep erosion.

Water retention upstream of low-lying areas is also mandatory in terms of benefits for those areas. In the case of agricultural areas characterized by heavy soils and higher or smaller slopes during rainy periods, water through the drainage on the slope causes soil erosion, with extremely unfavorable effects on soil fertility by moving the fertile superficial layer at the base of the slopes or in the collecting channels causing their clogging as well.

MATERIALS AND METHODS

The studied area is positioned in the Bârzavei Plain, located on both banks of the Bârzava River, stretching between Berecuța, Rovinița Mare and Denta, respectively Sculea, Opatița and Deta.

The relief characteristic of a divisive plain is made up of a succession of fluvial beams and fluviolacuster depression areas, characteristic of a continental delta.

The maximum altitude is 90 m in the south-eastern extremity of the plain in the connection area to the Gătaia Plain, and the minimum altitude of 80 m in the south-western extremity of the investigated territory at the border with Serbia and in some portions of the Bârzavei Meadow.

The general orientation of the relief forms is almost parallel to the SE-NV direction with a slight inclination in this direction, concordanced both with the flow slope of the Bârzava river and with the general slope of the plain that is directed towards the neotectonic zone of maximum leave on the territory of Serbia.

Situated between Timiș-Pogăniș-Bârzava, respectively Moravița, these physico-geographical subunits occupy an area of 96843 ha (tab.2.15.), respectively 87755 ha of agricultural land, occupying the highest part of the sub-colonial area, being formed by the convergence of subcolinear glacis, intensely modeled by a network of valleys (generally marshy or subject to floods), being found in 10 territorial administrative units (ATU): Birda, Denta, Deta, Gătaia, Jamu Mare, Liebling, Moravița, Nițchidorf, Tormac, Voiteni.

Table1. Situation of the land fund (ha/%)* from the basin of the Gătaia-Tormac-Moravița Plain

Spec	Arable	Pastures	Meadows	Vine yard	Orchards	Agricultural Total	Forests	Waters	Other categories	General total
Ha	69790	13085	3875	295	710	87755	3695	1107	4286	96843
%	72.07	13.51	4.01	0.30	0.73	90.62	3.82	1.14	4.42	100
	79.53	14.91	4.41	0.34	0.81	100	-	-	-	-

The general orientation of the interfluves and erosion valleys is almost parallel in the south-east-north-west direction with a slight inclination in the same direction towards the Bârzava River. These plains generally present a mature relief at the level of the interfluvia and recently at the connection with the erosion valleys, meadows and low plains.

Their relief falls in steps from east to west constituting a transition relief between the structural erosive piedmont relief within the interfluvia towards the accumulative fluvial relief of subsidence and divagation of the low plains.

RESULTS

From the geomorphological point of view, the Denta plain is part of the great physical-geographical unit of the Tisza plain, more precisely in the central part of the Banat Plain in the Middle Hydrographic Basin of the Bârzava River and stretches in the eastern and south-eastern part of the Denta territory in the basin of the Bârzavei tributary known locally as Beghin and represents the lowest part of the Gătaia plain.

Its marginal location at the contact between the Piedmont High Plain on the one hand and the low divisive Plain and the Bârzava meadow on the other side, the natural conditions (relief, lithology, hydrology and vegetation) are those specific to a transition plain, accumulation and transition.

The relief of the Gătaia Plain falls in steps from east to west and on the territory of denta commune it overlaps almost entirely on the lowest step of the altitudes between 90 and 112 m, constituting a transition relief between the structurally erosive piedmont south within the high plain to the accumulative river relief of subsistence and division of the Denta Low Plain.

In the Denta territory it takes place in the south-eastern part of it and overlaps entirely under the hydrographic basin of the Beghin river tributary of Bârzava river.

Its surface has the appearance of a vast piedmont plain that presents itself as a succession of quasi-urban interfluvial fields with a width of 200 to 2000 meters crossed by shallow erosion valleys with short discharges, with slopes that rarely exceed 5% and narrow meadows with the appearance of alluvial divisional plains with a width of 50-500 m.

The maximum altitude is 90-112 m at the interfluvial level, and the minimum altitude is 80-90 m at the level of the floodplains in the erosion valleys.

The general orientation of the interfluves and erosion valleys is almost parallel in the south-east-north-west direction with a slight inclination in the same direction on the Bârzava River, this plain on the Territory of Denta at first sight almost has a relatively flat surface.

However, carefully researched it is found that it presents frequent bumps represented within the horizontal and quasi-zonal surfaces within the interfluvia of numerous crevices tamped with loess, long depression areas located in the upper part of the erosion valleys. Due to this varied microrelief, the surface of the interfluvia is presented with numerous puddles and excess of umidity.

The geology of the Banato-Crisana plain, of which the Gătaia plain is a part, is a unit developed on a crystalline Carpathian foundation submerged in miocenes at different depths and intensely fragmented by a system of foils that are shave through the presence of neo-eruptive massifs that are up to date in several places, such as the basalt ones south of the Gătaia from the Long Hill.

The crystalline foundation is discordantly covered by a pliocene-cuathermal sedimentary blanket with variable thicknesses, formed by a succession of fluvial-lake pliocene deposits (clays, sands, gravels).

Over these deposits were deposited pleistocene aluvio-proluvial materials in the form of large manure cones with thicknesses up to 50-80 m, the structure of the deposits presents a considerable intake of material from the mountains and the Piedmont hills through the hydrographic network that, starting from Levantin, had the main role in clogging the Pannonian Lake and in the formation of the plain. At the same time, the deposits reflect the alternation of the erosion and transport pits with intense accumulation phases especially in the higher part of the eastern plain, due to the withdrawal of the Pannonian Lake as a direct consequence of the rhythmic lifting movements of the neighboring mountains and hills, as well as of the subsistence movements in the plain.

From the hydrographic point of view, the investigated perimeter is part of the group of south-western hydrographic systems, the Bârzava Timiş hydrographic basin Bârzava River with a length of 127 kilometers, has its origin on the Northern and western slope of the Semenic Massif at an altitude of 965 meters. Bârzava is a river with small tributaries, the average width of the reception basin on the territory of our country is only 7.5 kilometers.

Downstream of Denta and Deta, the Bârzava course has been regularized since the end of the eighteenth century, and currently on this sector, its course is tense between dams whose length reaches 11.5 kilometers on the left bank and on the right bank 13.9 kilometers

Such a water regime favored by the subsistent character of the area it crosses, has caused divisions and drownings, posing the problem of taking defensive measures.

Thus, the hydro-ameliorative works started over two centuries ago and mentioned in the above rows in order to remove the excess of moisture were completed with three drainage systems: the Bârzava Mijlocie System, the Partoş System and the Banloc System.

The use of the river for irrigation is since 1801 when to the west of Deta was born the Topolea rice farm (today the Banloc rice mill), the entire quantity of water being taken over through the Italian canal that branched upstream of the commune Denta.

The streams, Iunca and Birda, the main courses in the north of the investigated perimeter, have that feature the maximum flow flows, forming especially from the spring rains and the beginning of the winters and the minimum leakages are recorded in the drought periods during the summer when the springs barely trickle. Due to their torrential character until the mentioned period, they trained appreciable amounts of coiluvial material that produced changes inseminated to both textural and fertility indicators.

The existence of the groundwater close to the soil surface (0.5-2 meters) with the very slow and often stagnant drainage determined the arrangement of the South Lunca Birda dewatering system with a total area of 11388 hectares.

In addition to the presented watercourses, the hydrogradic network from the Denta plain to the investigated territory is represented by a series of deserted riverbeds and meanders, as well as a vast network of drainage channels that discharge mostly from Bârzava.

The canals are generally filled with water and only locally in the areas of the grinds the water disappears during dry periods. In the southern part, the plain is drained by the channeled pine and dammed Beghin tributary of the Barzava which drains through its tributaries the High Gătaia Plain.

A very important feature of the investigated area is represented by its hydrographic situation which is highlighted by:

-the presence of groundwater close to the surface in the low and middle area of the plain.

-the hydrographic level of the very unstable groundwater which during the year can rise several times to the surface, giving rise to processes of secondary solinization, gleaming or even inmatination of the soils in depressions and low places.

-the existence of groundwater under pressure, enclosed between impermeable alluvial pates.

The groundwater is generally mineralized, generally containing inseminated amounts of sulfates, chlorides and carbonates, resulting from the water samples collected from the investigated territory.

The characterization of the climatic conditions of the studied area was made on the basis of the data recorded at the Timisoara meteorological station in the period 1971-1975 with the mention that the temperature of the area is somewhat lower than the one presented, and the precipitations higher. (Timisoara meteorological station is the closest station to the studied area).

The thermal regime is highlighted by the average annual temperature which is 10.6 degree Celsius.

Table 2. Average monthly temperatures (degree Celsius), for the period mentioned above osciliasis as follows:

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
-1.9	0.3	5.5	11.1	16.0	19.5	21.6	20.6	16.8	11.2	5.5	0.7

Under the influence of mediterranean and oceanic air masses, winters are shorter and milder. Average temperature in winter (0.2 degree Celsius). Springs are early, warmer but short with large variations in temperature. Average temperature 11.2 degree Celsius. Summers are long and warm, the average temperature is 20.7 degree Celsius, the warmest month being July when 21.6 degree Celsius is recorded. Autumns are also long, favorable for harvest gatherings, the average temperature 11.3 degree Celsius, generally more constant temperatures than during the spring.

The lowest average decadal temperature is recorded in the third decade of January and the highest in the third decade of July.

The first frosts appear on average in the third decade of October ,and the last in the second decade of April. The average duration of the interval without frost is about 190 days.

The extreme dates of the autumn frost are:

- the earliest; 4.X.
- at the latest; 21.X.

The extreme dates of the spring frost are:

- the earliest; 23.III.
- at the latest; 19.V.

The first frosts appear in autumn at the end of September and the last in the second half of April and exceptionally in May (second decade)

Pluviometric regime

The average annual rainfall is 631mm. Annual rainfall recorded at the meteorological station in Timisoara.

Table 3. Monthly rainfall recorded

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
38.5	36.2	39.1	52.2	68.5	84.2	60.6	50.4	46.9	55.0	50.3	49.7

There are characteristic nuances even if the differences in precipitation are small.
In summer, an average of 193.3 mm of water falls, compared to spring they are larger by about 30 mmm.

In autumn, the rainfall that falls are on average 150.5 m and are lower than in summer by about 40-45 mm.

In winter the precipitation is the lowest 128.9 mm, they are due to the activity of anticyclones.

In spring, there is 158.3 mm of precipitation that slightly exceeds the autumn ones. The potential and real evapotranspiration of monthly and annual averages in Timisoara (1896-1955) after TORNTHWAITE is as follows:

Table 4. Potential evaporation for each month

E/L	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	anual
Pot	0	1	23	53	97	123	135	123	81	44	16	2	688
real	0	1	23	53	97	123	85	52	47	44	16	2	544

Table 5. Surplus and deficiency of soil moisture compared to the poential evapotranspiration for each month

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	An
Exces	29	39	19	0	0	0	0	0	0	0	0	0	78
Deficit	0	0	0	0	0	0	49	71	34	0	0	0	154

The influence of the anthropic factor

The anthropogenic influence is reflected in the continuous development of agriculture and imposed an increasingly intense use of soil resources, which associated with an intense mechanization, fertilization and hydro-improvement planning of the territory within the investigated perimeter determined the modification of the conditions of natural development of pedogenetic processes and soil properties.

The most important changes in the conditions of pedogenesis are due to: the regularization, sewerage and impoundment works associated with the dewatering-drainage and irrigation works (started about 200 years ago). To these were later added the replacement of vegetation by agricultural crops, the admission of mineral fertilizers on an increasing scale, the intensive work of the soil with mechanical means (often indiscriminately using heavy machinery on insufficiently dry terrain), diminishing the areas occupied by perennial grasses and legumes.

All these interventions of man have changed the regime of nutrients and the water regime of the soil, including the circulation of water both on the surface and inside it. As such, the circuit and the balance of the elements in the soil layer have changed their pace of development or are in the process of being modified according to the conditions of evolution.

Of particular importance for raising the potential of production and soil resources within the investigated perimeter are the works on preventing and combating the excess of groundwater from precipitation.

Thus, the hydro-ameliorative works started over two centuries ago have known a special magnitude nowadays, the investigated perimeter being almost entirely furrowed by a vast network of drainage channels that discharge mostly in Bârzava.

They had a favorable effect on the pedogenetic processes, but they did not solve the problem of excess moisture in full (new executions are currently taking place).

In order to ensure the protection and elevation of soil qualities through its production activity, man will have to favor in the soil processes that lead to the concentration of nutrients and argovile matter. Thus, in order to prevent the physical degradation of the soil, it is necessary to reduce to the minimum necessary the soil preparation works, to carry out agrotechnical works at the optimum moisture of the soil, to ensure a structure of ameliorative plant crops.

The acidification of the soil as a result of the long administration of some fertilizers and nitrogen will be avoided by replacing on these soils the nitrogenous fertilizers with acidification potential with others without such potential.

Also, taking into account the fact that a large part of the soils of the investigated perimeter are successively affected within the same period of excess vegetation and moisture deficit on the agricultural production, the specific technologies will target both aeration porridges and water permeabilities through loosening works bringing associated agrotechnical works carried out on time and of good quality.

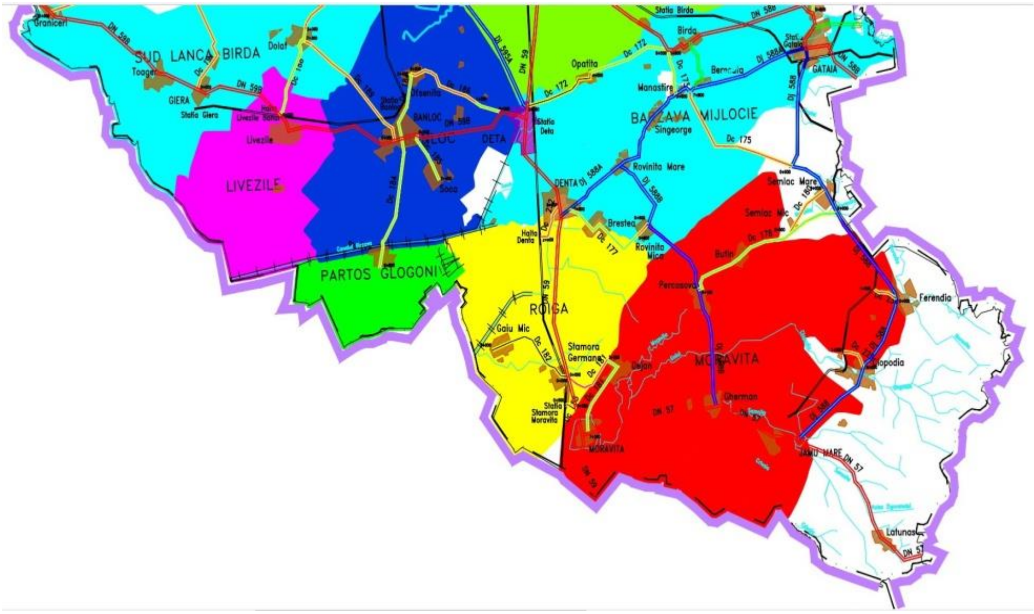

Figure 1. Situation plan with the areas developed with land reclamation works in Timis County

Also, taking into account the fact that a large part of the soils of the investigated perimeter are successively affected within the same period of excess vegetation and moisture deficit on the agricultural production, the specific technologies will target both aeration porridges and water permeabilities through loosening works bringing associated agrotechnical works carried out on time and of good quality.

From the existing data it follows that in the summer period there is a deficit of moisture that must be covered by an additional intake of water by irrigation.

Soil evolution

By the repeated change of their riverbeds and by the frequent outpourings these rivers deposited new material of an alluvial nature on another already undergoing solification. Thus the soils of the alluvial plain appear in the form of alternate layers differently soiled. After the impoundment of the rivers, these alluvials were stopped, thus beginning the processes of solification.

These processes that led to the formation of the present soils took place under the dominant influence of the groundwater.

Thus, in this area, which until the realization of the current network of canals begun in the middle of the XVIII century by the regularization, sewerage and impoundment of the main courses, was periodically flooded, the excess of moisture preventing the penetration of oxygen into the soil, and anaerobic microorganisms, the only ones that can live in these conditions taking the oxygen they need in their activity of decomposition of organic matter from various mineral compounds (especially iron and manganese) giving rise to the processes of reduction resulting in ferrous and manganese oxide.

These iron compounds, if the excessive wetting is long-lasting in reaction with silica, form secondary minerals of bluish green color of ferrosilicates type. These minerals give the characteristic color to gleic horizons. As a result of gleization processes, hydromorphic soils characterized by the horizons Am (Ao), Go, Gr were formed.

On some portions as a result of the processes of lowering the phreatic level, through the network of channels performed lately, the phenomenon of gleization appears in relict form.

Nowadays hydromorphic soils are found in depression forms, where waters have stagnated for longer period of time.

In the drained portions, the excessive wetting is of little duration and so at a time of the year the oxygen enters the soil. In contact with it, the compounds of iron and manganese reduced in the previous period of excessive wetting oxidize and precipitate as reddish brown or rusty hydroxides.

The oxidation processes are therefore predominant, there is even a leaching of salts, the soil profile evolving thus towards the type of zonal soil.

Precipitation evolutions in the area studied in the last 10 years

In order to analyze the evolution of precipitation, in the last ten years we have used the data recorded in the NLRA (National Administration of Land Reclamation) pumping stations from the adjacent perimeters arranged with land reclamation works from the studied area.

The detailed analysis of the pluviometric regime over a period of 10 years, in the studied interval 2009-2019, revealed an anomaly of the monthly and decadal distribution of the amount of precipitations, there being periods with significant pluviometric quantities that alternated with dry periods, some periods being even long.

During the years 2009-2019 precipitation had an irregular character both in terms of monthly and annual quantities. There were reported months with very large quantities as well as months in which the rainfall amounts were insignificant or even 0 mm.

The year 2009 presented two very dry months (April and September) in which there were points where not a liter of meteoric water was measured. Thus, in Moravita, in April they have the case of 0 l / sqm.

In September, precipitation was null at Banloc, Deta. In contrast, the month of June was rainy, with downpours exceeding 130 l / sqm (Deta 137 mm).

The year 2010 was the wettest of the analyzed string. Thus, at SP Galatca compared to a normal of 618 l / sqm fell 1330 l / sqm. The months of May and June were surplus with precipitations exceeding 230 l / sqm / month, up to values of 271 l / sqm in May at Galatca.

The year 2011 was one of the driest years in the last 50 years. In the whole year, precipitations fell, which in rainy years were reported in a single month (Cenei 194 l / sqm,).

The years 2012-2013 were relatively close in dynamics of precipitation and close to the multiannual quantities. It stands out in March of 2012 with small amounts of rainwater with values from 0.6 l / sqm at Cebza and Cenei.

As dry as well it was also December 2013 with precipitation values between 0.5 l / sqm at Comloșu and 5 l / sqm at Banloc.

March of 2013 was completely opposite to March 2012, registering high meteoric water values of 166 l / sqm at Cenad.

The year 2014 was a rainy year, in which there were rainfall stations where the amount of precipitation exceeded 1000 l / sqm (Cenad 1156 l / sqm). The rainy months were May and July when the rainfall exceeded 200 l / sqm reaching over 257 l / sqm at Cenad.

The months of April and July of 2015 had low rainfall, below the climatological norms.

In 2016 it was rainfall above the norm. The warm season was rainy, with rainfall that in June was well above the monthly averages. Many of the pluvious stations had quantities of over 200 l/sqm (Cenei 266 l/sqm)

December was dry with precipitations that only isolated exceeded 10 l / sqm (Chevereșu 10.9l / sqm).

The year 2017 was a deficient one in terms of rainfall. The first month of the year had precipitations that did not exceed 15 l / sqm and even February did not excel in terms of rainfall.

Regarding the amount of rainfall fallen, the year 2018 was a year close to normal. Summer was rainy with exceptional quantities in June (SP Moravita - 254 l / sqm).

*Table 6.*Values with heavy rainfall recorded (mm), May and June 2019 at the stations in the studied area

Crt. No.	Stationary	May	June	**Total/Year2019**
1.	SP Cruceni	166.6	93.7	**548.6**
2.	SP Rudna	152.6	99.9	**560.2**
3.	SP Grăniceri	153.7	77.5	**547.2**
4.	SP Gad	147.8	104	**591.0**
5.	SP Cebza	146.4	71.5	**437.0**
6.	SP Banloc	134.9	89.8	**412.2**
7.	SP Livezile	153.9	161.2	**648.3**
8.	SP Partoș	172.4	56.4	**498.4**
9.	SP Topolea	140	80	**436.1**
10.	SP Moravița	100.5	66.6	**469.7**

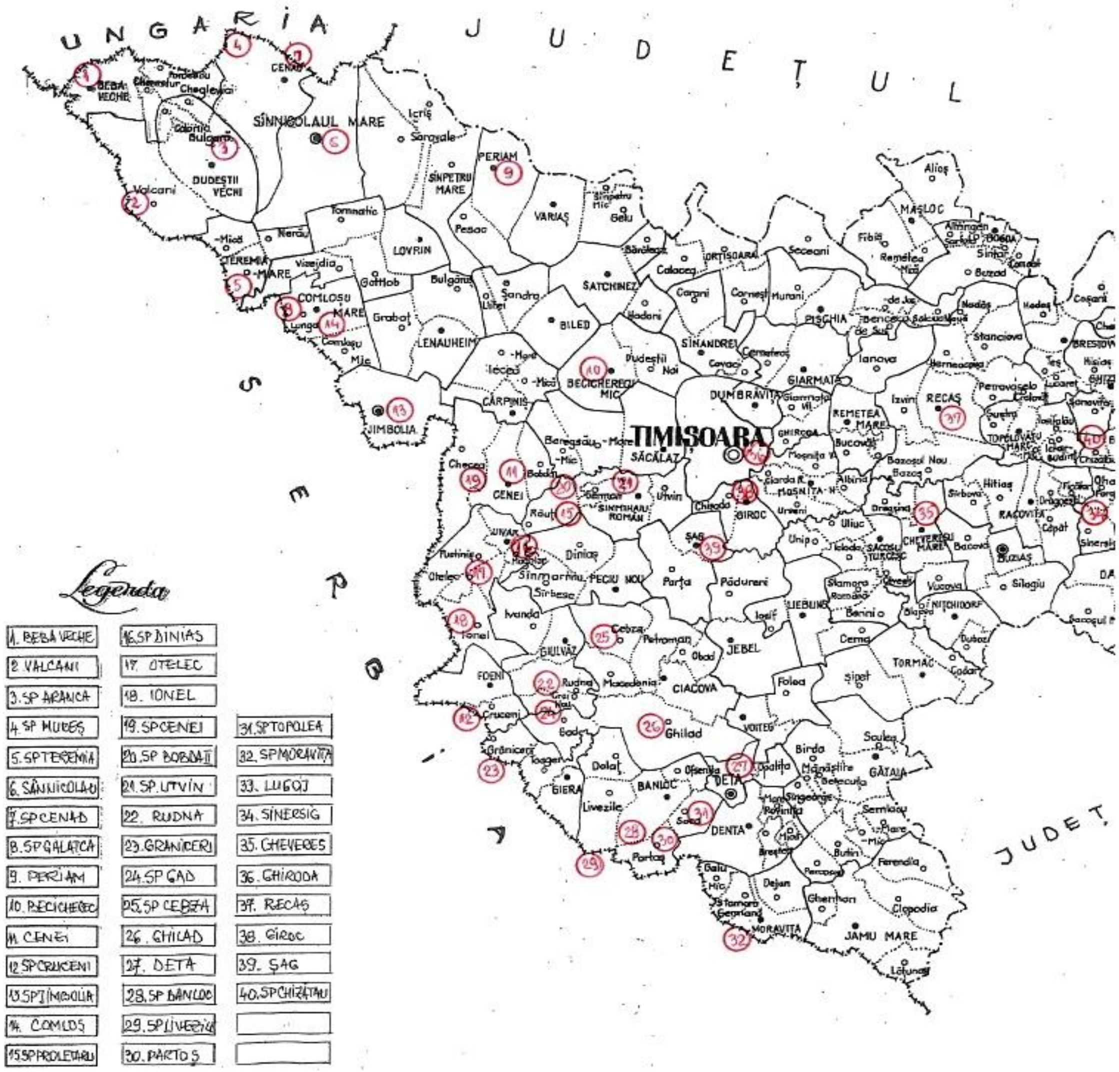

Figure 2. NRLA, Studied area pluviometer-pluviograph stations

We can conclude that the climatic developments of the last 10 years have anomalies in the distribution of precipitation:

- alternation of periods with excessive precipitation with dry periods;
- irregular character in terms of both monthly and annual quantities

Thus, the negative effects of excess water on agricultural crops are:

- additional soil and water pollution with fertilisers, herbicides and pesticides due to
- perimeter overlaps around the crevices;
- delay in sowing in the spring;
- loss of plants and/or areas through puddles;
- extension of the vegetative rest period for autumn crops;
- delay in reaching maturity;
- overlapping of water-critical phenophases of plants with warm and dry periods in the summer;
- favoring the attack of diseases as a result of excessive humidity;
- poorly developed root system;
- multiplication of hydrophilic weeds;

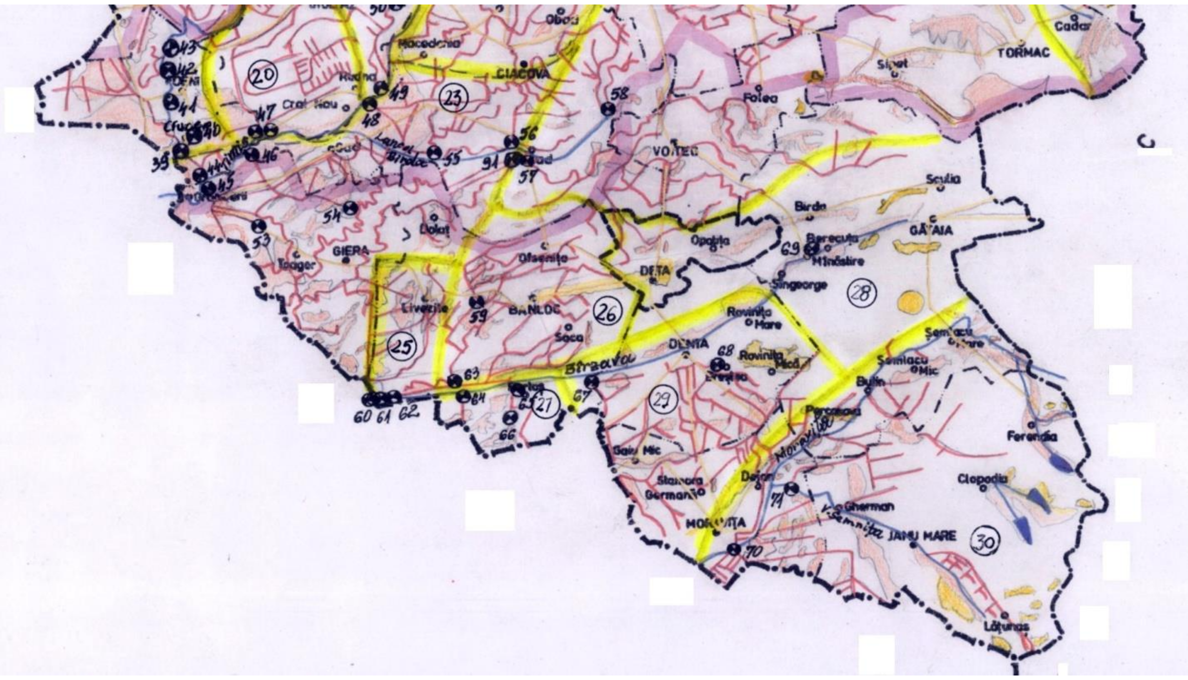

Figure 3. NRLA, Studied area pumping stations

Negative effects of excess water on the sustainability of agricultural activities:

- degradation of soil quality;
- additional technological costs
- the need to equip with equipment for the execution of agricultural works in the shortest possible time;
- low yields;
- additional soil and water pollution;
- additional CO_2 pollution by increasing fuel consumption.

DISCUSSION

The activity of protection against floods caused by internal waters (precipitation from rains and snow melting) is a primordial activity, it is an end in itself in the complexity of the field of activity of our institution, it is an objective that must be taken into account all the time for reasons that leave no room for interpretation.

This arguments that come from different spheres (economic, human, social) converge in one direction, respectively in making efforts to prevent the respective situations, or if they (the floods) have occurred, to quickly remove the effects and restore the normal exploitation regime (functioning) of the works.

After 1989, the allocation of insufficient funds for the maintenance of these facilities, many of them made at the technical and knowledge level of the years 1970 - 1980, determined the severe reduction of their functionality, due to the clogging of the canals, the growth of vegetation specific to wetlands, the deterioration of hydrotechnical constructions and pumping stations.

The consequences of this facts of affairs are amplified, year by year, by the extreme climatic developments, characterized by the alternation of periods with excess-deficit of precipitation.

The more important negative effects are:

- soil degradation (compaction, secondary salting, pollution and erosion by leakage to the surface, etc.
- impossibility to carry out agricultural works on time and in optimal conditions;
- increasing the risk of flooding crops;
- losses of plants or crop areas through puddles;
- endangering the sustainability of agricultural activities in these areas.

The presented ones have, in the end, negative effects on the quality of life of the inhabitants, and in the medium and long term, they can lead to the reduction of the cultivated areas.

However, the rehabilitation of the hydro-ameliorative facilities in the low plain area of South-West Romania cannot fully solve the problems generated by the excess and the deficit of moisture in the soil.

In addition, two sets of measures are required:

- reducing the water intake coming from the higher neighboring areas by retaining it in customized tanks as the case may be;
- the application by farmers of an agrotechnical specific to this area, based mainly on deep aerations, land leveling and appropriate rotations.

Water retention upstream of low-lying areas is also mandatory in terms of benefits for those areas. In the case of agricultural areas characterized by heavy soils and higher or smaller slopes during rainy periods, water through the drainage on the slope causes soil erosion, with extremely unfavorable effects on soil fertility by moving the fertile superficial layer at the base of the slopes or in the collecting channels causing their clogging as well.

The lost water causes the drought phenomenon to set in quickly after the rainy season. Where there are orographic conditions, it is necessary to retain the excess water in small storage dams, and in the dry season it will be used for irrigation. The loss of water through the drainage on the slopes can be greatly reduced also by applying a specific agrotechnics of the sloping lands, the benefit being dual:

-increasing productions in these areas and limiting erosion;

-reducing the quantities of water that reach downstream, in the low plain exposed to excess moisture.

Some proposals for the maintenance and keep in operation of land reclamation systems

1.Carrying out agro-pedoameliorative works in parallel with the maintenance of the canal network
2.Endowment with equipment and related means of transport for the maintenance and repair of land improvement works from the patrimony administered by NLRA.
3.The introduction of land improvement fees (fees) (according to L 138/2004) – as a financial source for supporting the maintenance and repair of the IF works to which all the beneficiaries of the IF works contribute (IF fee), the IF fee is applicable only under the conditions of concluding contracts with the land beneficiaries – to which many beneficiaries those located upstream, they are not interested, but benefit from the works. The value of the tariff (fee) is maximum 30 Euro / ha / year depending on the way of water evacuation: gravitational or by pumping.
4.Financial support for the payment of IF fees from the environmental fund (finally all these hydro-pedoameliorative measures contribute to the protection of soil and water);
5.Compliance with the regulations for the operation of the facilities;

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*** Arhiva ANIF - Date, anuare, statistici

THE EFFECTS OF LAND USE AND LANDCOVER ON WATER QUALITY IN THE RAKOS CATCHMENT, HUNGARY

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ABSTRACT

Investigation of the relationships between land-use allocation and water quality preservation within a catchment is an essential issue for sustainable watershed management. The land use and land cover of the Rakos catchment have been changed gradually over the last few decades. Changes in land use and land cover (LULCCs) can have significant effects on water quality particularly on surface water quality and degradation, which can be caused by surface runoff from artificial, agricultural areas, and sewage discharges from urban sprawl and agro-industry. This research aims to evaluate the impact of LULC on surface water quality in the Rakos catchment. In this regard, the assessment of the LULC changes was performed using the CORINE land cover dataset, and the water quality data was obtained from the water quality monitoring of Rákos stream along seven sampling points, starting from its source in Gödöllő to the outskirts of Budapest in a semi-urbanized area. The findings show that there are increases in NO_3 and PO_4 concentration in the third sampling point which is surrounded by more agricultural areas. These results in the Rakos catchment demonstrate that the importance of addressing water quality impacts caused by land use should be considered in the environmental planning process to reduce water resources issues.

Keywords: Water quality, CORINE, land cover, watershed management

INTRODUCTION

Land use and water resources are inextricably linked. The relationship between land use and water resources is complex. The hydrological processes that transfer net rainfall to river flows and groundwater recharge vary with soil, topography, rainfall characteristics, and hydrogeological properties (Anderson and Burt, 1978; Dan, 1978). In each given catchment, a combination of processes controls the transfer of water to groundwater canals and rivers. The resulting streams may include components of very different hydrological flow paths, including direct runoff, shallow flow with a residence time of several days, and groundwater baseline flow with a residence time of years or even decades (Weatherhead and Howden, 2009).

Water resources are key factors of sustainable development. Rapid population growth in recent years has led to increasing water demands. Unsustainable development pathways and governance failures have affected the quality, quantity, and availability of water resources (Kundu et al., 2017). Increasing population rate, unplanned urbanization, land use, and land cover changes have been recognized as the most important challenges for water resources management (Shrestha et al., 2018). Land use and land cover (LULC) changes modify the basin hydrology by affecting evapotranspiration, soil infiltration capacity and surface and subsurface regimes which ultimately affect water quantity and quality (Cuo et al., 2013). Moreover land-use change is one of the most critical and direct driving factors of changes in ecosystem functions and services (Burkhard et al., 2012; Kindu et al., 2016). It can change the ecosystem productivity, modify the physical parameters of the earth's surface, affect nutritional convey between soil and vegetation by changing biochemical cycles, and influence the element and structure of ecosystems (Zang et al., 2011).

Investigation of the relationships between land-use allocation and water quality preservation within a catchment is an essential issue for sustainable watershed management. The land use and land cover of the Rákos catchment have been changed gradually over the last few decades. Changes in land use and land cover (LULCCs) can have significant effects on water quality particularly on surface water quality and degradation, which can be caused by surface runoff from artificial, agricultural areas, and sewage discharges from urban sprawl and agro-industry.

MATERIAL AND METHOD

This research aims to evaluate the impact of LULC on surface water quality in the Rákos catchment. In this regard, the assessment of the LULC changes was performed using the CORINE land cover dataset of Hungary. The entire land cover data set was analyzed first in QGIS to obtain the area of each category of land uses of the study area in 2018, and the water quality data was obtained from the water quality monitoring of Rákos stream along seven sampling points, starting from its source in Gödöllő to the outskirts of Budapest in a semi-urbanized area. The sampling points are distributed before and after areas with predominant land-use types upstream and after some important points such as point 3, which is right after the Pécel wastewater treatment plant. Point 1 is the starting point for the continuous urban area of Budapest and point 8 is at the source of the creek on the outskirts of Gödöllő. Both parameters were measured in situ, nitrate, and phosphate were measured using the Macherey-Nagel PF-12Plus Compact photometer with Visocolor Eco test kits. Figure (1) shows the geographic location of the study area and the location of the sampling points.

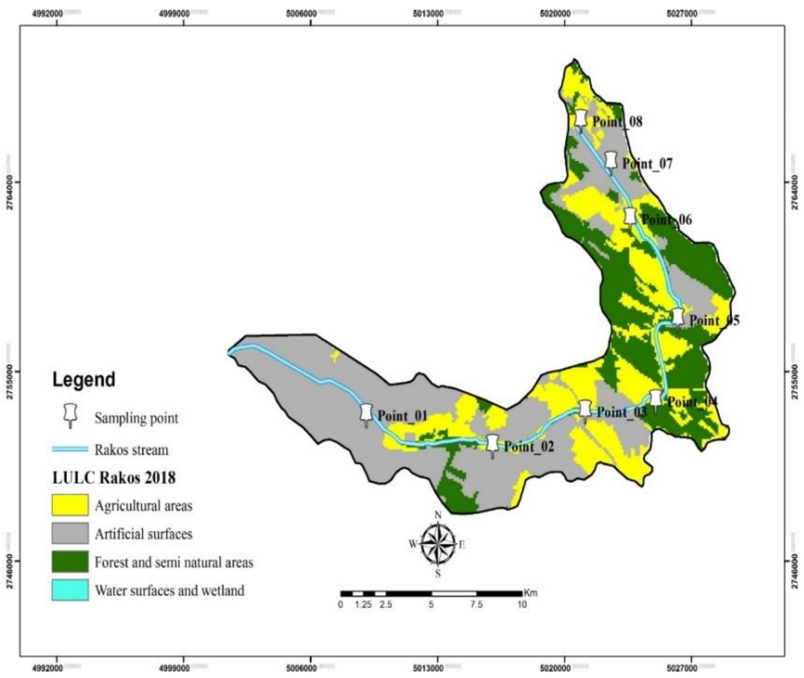

Figure 1. Geographic location land cover of the study area

RESULTS AND DISCUSSION

Figure 2 presents the concentration of NO_3 and PO_4 in different sampling points. The findings show that there are increases in NO_3 and PO_4 concentration in the third sampling point which is surrounded by more agricultural areas. According to the results of water quality monitoring in the study area, the stream is clearly influenced by different sources in all of its length

These results in the Rákos catchment demonstrate that the importance of addressing water quality impacts caused by land use should be considered in the environmental planning process to reduce water resources issues.

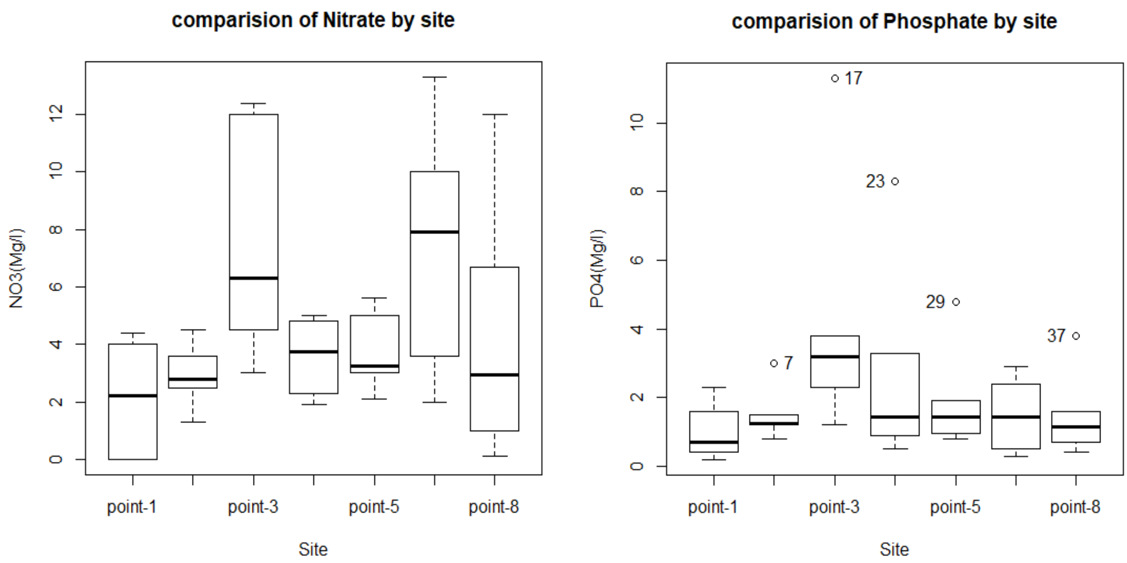

Figure 2. The concentration of NO_3, PO_4 in different sampling points

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EXPERIENCES OF THE WATER PROTECTION EFFICIENCY OF THE AGRI-ENVIRONMENTAL MEASURES IN THE HUNGARIAN RURAL DEVELOPMENT PROGRAM

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ABSTRACT

The proper condition of surface and groundwater is crucial for the sustainability of human life, including agriculture, therefore the Rural Development Program, RDP (2014-2020) allocated significant subsidies to achieve water protection objectives. We first examined the willingness of farmers to choose RDP measures with different water protection efficiencies. We also used GIS analyzes to examine the extent to which the RDP measures were implemented in the erosion, inland water and drought-sensitive areas designated in the agri-environmental schemes (AES) at the proposal of the national river basin management plan. We also examined the extent of the RDP's water protection measures were implemented in critical areas in terms of water quality (on surface and groundwater bodies in poor condition based on the basis of National River Basin Management Plan). The analysis found that adequate support is available in the rural development program for water-sensitive areas, but that farmers' interest in these targeted programs is relatively low and there are meagre supported areas in catchment areas of surface water or groundwater which is in poor condition. By modifying the tender conditions, the water protection efficiency and effectiveness of the measures can be doubled or tripled.

Keywords: rural development planning, agri-environment measures, water protection, efficiency

INTRODUCTION

Our hydrogeographical features are characterized on the one hand by significant relative advantages and on the other hand, by a high degree of vulnerability which is rooted in the hydrographic unity of the Carpathian Basin and its division with political boundaries. Due to the significant amount of water coming from large rivers in Hungary, the per capita water supply is one of the largest on the continent, while our 'own' water supply from precipitation is one of the smallest. We have good quality, and in some areas abundant groundwater resources, but in some places there are already signs of overuse. We have large areas of valuable wetlands, and our shallow lakes have significant tourism potential. However, our surface water network is rare in relation to demand. The proportion of irrigated areas is very low, also lagging behind the EU and the US.

Although the conservation and sustainable use of our waters is of strategic interest, the ecological status of our waters and water-dependent wetlands and terrestrial habitats is moderate, falling short of the expected 'good status' in both qualitative and quantitative terms. This is particularly important in the light of climate change, which will increase the need for conscious water management in agriculture. In the case of our large rivers (Danube, Tisza), comparing the water quality measured in the entry and exit sections of the country shows that the impact of foreign loads is significant, however, water quality problems due to point and diffuse pollution characterize small waters in much higher proportion, which is independent of foreign loads. The origin of the nutrient load of surface waters is mainly of diffuse agricultural origin and of point source emissions from municipal wastewater.

The EU Water Framework Directive (WFD) required the achievement of good water status by 2015. This deadline can be extended to a maximum of six years, with due justification, so that the environmental objectives must be achieved by 2027 at the latest. In addition to the WFD, the EU Nitrates Directive aims to protect water quality from nitrate pollution of agricultural origin in soils and surface and groundwater across Europe by encouraging the application of good management practices.

MATERIALS AND METHODS

The proper condition of surface and groundwater is crucial for the sustainability of human life, including agriculture, therefore the Rural Development Program (RDP), 2014-2020 allocated significant subsidies to achieve water management objectives.

There are two major packages of agricultural interventions to reduce agricultural pressures:

1. the RDP, which directly supported water protection and sustainable agricultural water management with a total of 18 measures, and
2. Good Agricultural Practice for Nitrate Vulnerable Zones, the statutory management requirements (SMRs) and Good Agricultural and Environmental Condition (GAEC) to be introduced under the Single Area Payment Scheme (SAPS), together the system of ’cross compliance’.

The following table summarizes the measures contributing to the achievement of the water protection and sustainable agricultural water management objectives, supported in the RDP and examined in the evaluation.

We first examined the willingness of farmers to choose RDP measures with different water protection efficiencies. We also used GIS analyzes to examine the extent to which the RDP measures were implemented in the erosion, inland water and drought-sensitive areas designated in the agri-environmental schemes (AES) at the proposal of the national river basin management plan. We also examined the extent of the RDP's water protection measures were implemented in critical areas in terms of water quality (on surface and groundwater bodies in poor condition based on the basis of National River Basin Management Plan).

RESULTS

Results of area-based measures related to agricultural areas

Some of the measures of the RDP containing water protection regulations are area-based agricultural support, the total area of which reached about 981 thousand hectares. The supported areas of forest management measures concerning water protection amounted to about 125 thousand hectares. These were supplemented by the greening standard enforced under the SAPS on 512 thousand hectares. Thus, the areas affected by water protection regulations totalled more than 1,600,000 hectares.

Table 1. The connection of the examined RDP measures to water conservation and sustainable agricultural water management

		I. Water protection				II. Sustainable field-economic water management
Measure	**Shortened name of measure**	**1. Nutrient management**	**2. Surface water quality**	**3. Ground-water quality**	**4. Water retention**	
Area-based rural-development measures related to agricultural land						
M10.1	Agri-environmental management	**X**	**X**	**X**		
M11	Organic farming	**X**	**X**	**X**		
M12.1	Natura 2000 Agricultural	**X**	**X**	**X**		
M13.2	Compensatory payment of areas with natural handicaps	**X**	**X**	**X**		
Non-producing investments, landscape management						
M4.4.1	Habitat development investments	**X**				
M4.4.2.1	Water protection facilities		**X**		**X**	
M4.4.2.2	Development of wetland habitats		**X**		**X**	
M16.5	Landscape management				**X**	
Fertilizer treatment and sewage treatment						
M4.1.1.6	Construction of manure storage		**X**	**X**		
M7.2.1.2	Individual waste water treatment		**X**	**X**		
Forest management measures affecting water protection						
M08.1	Support for afforestation		**X**		**X**	
M08.2	Agri-forestry systems		**X**		**X**	
M08.5	Forest ecosystems		**X**		**X**	
M12.2	Natura 2000 forest areas	**X**	**X**	**X**		
M15.1	Forest-environment protection		**X**			
Sustainable agricultural water management measures						
M4.1.4	Agricultural water management				**X**	**X**
M4.1.3.2	Horticulture modernization with irrigation				**X**	**X**
M4.1.3.6	Wine grape plantation installation with irrigation				**X**	**X**

Source: Own editing

The effectiveness of the interventions can be characterized by the following quantifiable findings.

In SAPS areas, farmers have to comply with three sets of standards: the statutory management requirements (SMRs) and the Good Agricultural and Environmental Condition (GAEC), and the minimum requirements for "greening".

In the case of SAPS (GAEC regulations) it is also expected to preserve the terraces against erosion and to cover the soil either with autumn culture or cover crops, or with the preservation of the stubble until 30 September, with shallow stubble cultivation and medium soil loosening.

Table2. Application of the optional measures of the SAPS "greening" in proportion to the total area supported

„Greening" elements	Area supported, ha	Percentage of SAPS total area %	Number of element applied, db
1-fallow land	72 515.87	1.61%	28 113
3-hedges or wooded strips	362.52	0.008%	3 561
6-trees in groups	105.36	0.002%	731
7-field margin	246.57	0.005%	2 093
8- ponds	33.91	0.001%	147
10-other landscape features	71.21	0.002%	132
12-buffer strips (stagnant water)	3.26	0.000%	18
13-vízvédelmi sáv (watercources)	23.56	0.001%	269
15 –strips along forest (with production)	51.76	0.001%	177
16 – strips along forest (without production)	82.66	0.002%	279
17-areas with short rotation	348.66	0.01%	70
18-afforested areas	10 738.34	0.24%	2 336
19-catch crops or green cover	274 824.47	6.10%	37 412
20-nitrogen-fixing crops	152 354.57	3.38%	37 074
Total:	**511 762.73**	**11.35%**	**112 412**

Source: Own editing based on the data of the Hungarian State Treasury

The greening program introduced in the SAPS, which obliges the designation of 5% ecological significance above a certain parcel size (15 ha). It offers as a potential option a number of effective measures that are extremely important for water protection: for example, afforestation, water protection strips and field margins. The elements are optional, it can be seen from the following table that farmers have indicated almost only the catch crops or green cover or nitrogen-fixing crops, and the proportion of the total area of these is less than 10%. The effect of the catch crops is also positive, but it alone (with 5% territorial extension) is not enough.

A total of 35% of the RDP's area-based rural development support (agri-environment and climate measures, organic farming, Natura 2000 payments and payments related to the Water Framework Directive, and payments for areas with natural handicaps or other specific handicaps) was implemented in a sensitive water protection area demarcated in the Agricultural Parcel Identification System on the basis of the National River Basin Management Plan (hereinafter NRBMP). Agri-environmental measures were implemented in the most erosion-sensitive areas (about 187 thousand hectares), which in turn is only 7.3% of the delimited erosion-sensitive areas of significant size. If we examine the source areas with a diffuse load endangering the potential surface waters according to the WFD, about 40.8 percent of the supported measures were implemented in river basins at risk for surface waters.

Table 3. Extent of area-based support for rural development affecting water protection in areas with water sensitivity

Call for proposals	**Area supported (ha)**	from this in erosion-sensitive area	from this in inland water-sensitive area	from this in drought-sensitive area	Total in sensitive area*	Ratio (supported / total)
VP4-10.1.1-15/VP4-10.1.1-16 AES	580 253	110 984	47 623	37 503	187 392	32%
VP4-11.1.-11.2.-15 and 18 ÖKO	192 412	39 518	22 058	17 720	73 687	38%
VP4-12.1.1-16 - N2000 arable land	301 295	25 257	50 440	28 590	98 928	33%
VP4-13.2.1.-16 - THÉT	167 950	31 738	20 538	20 068	65 905	39%
Total*:	**980 904**	**187 210**	**95 923**	**78 588**	**341 267**	35%
Extent of sensitive areas (ha)		**2 563 578**	**374 639**	**542 782**	**3 379 908**	
Supported area, % in sensitive area	(%)	7.3%	25.6%	14.5%	12.6%	

* Value calculated taking into account overlapping areas.

Source: Own editing based on the data of the Hungarian State Treasury

The agri-environmental shemes also included water-focused interventions, focusing on drought-, inland-water and erosion-sensitive areas, which were designated at the suggestion of the National Water Basin Management Plan. However, examining the areas supported, it can be stated that the support awarded in these thematic sub-programs (so-called thematic requirement groups) was minimal. The areas covered by these thematic sub-programs are summarized in the table below.

Table 4. Territorial coverage of water protection zonal AES thematic requirement groups

Territorial application	**Land use category**	**Special area category**	**Area (ha)**	**Ratio**
Zonal	arable land	drought sensitive area	1 459	0.25%
Zonal	Szántó	inland water sensitive area	743	0.13%
Zonal	Szántó	erosion sensitive area	4 759	0.82%
Zonal	grassland	inland water sensitive area	1 240	0.21%
Total zonal	**Total**		**8 201**	**1.41%**
RDP AES 2015, 2018	**Total**		**580 253**	

Source: Own editing based on the data of the Hungarian State Treasury

Overall, it can be stated that the agri-environmental activities implemented in the thematic requirement groups of water protection do not reach 1.5% of the supported areas, so the activity of applicants was very low in the case of these target programs.

According to the latest NRBMP discussion paper (NRBMP3, 2020), 57% of the country's territory is the surface-contact area of groundwater bodies that are in poor status or at risk of developing poor status. Within this, the proportion of agricultural land is 61%. During the RDP, about 20 percent of these areas were subject to some area-based measures with a positive impact on water protection (AES, Organic Farming, Natura 2000, areas with natural handicaps).

The nutrient management related to the AES subsidies, which according to the evaluation is also favourable from the point of view of water protection, was implemented on about 580 thousand ha. Under the SAPS EFA (ecological focus area), farmers applied an optional element of water protection-effective, optional measures on about 512 thousand hectares. The greening program introduced in the SAPS, which mandates the designation of 5% ecological focus area above a certain field size (15 ha), offers as a potential option a number of effective measures that are extremely important for water protection: for example, afforestation, water protection strips and field edging. The elements were optional, farmers indicated almost only secondary sowing and the cultivation of nitrogen sequestrants, and the proportion of all these areas is barely 10 percent. The effect of second sowing is also positive, alone (with 5 percent territorial extension) is not enough.

Results of investment subsidies

In addition to area-based payment, the Rural Development Program also supported a number of investments to promote water protection:

- Under call VP-5-4.1.1.6-15 - Development of the livestock sector - construction of manure storage facilities, in 222 cases, more than 15 million EUR was used to modernize manure storage technology, thus reducing the chances of point source pollution of groundwater. Supporting the modernization of manure disposal on livestock farms, in line with the requirements of both the Nitrates Directive and the Water Framework Directive, remains an important task.
- Call VP6-7.2.1.2-16 developed wastewater treatment technology in 74 municipalities using more than 28 million €. In these cases, too, the risk of point groundwater pollution is expected to decrease.
- New afforestation on about 10,692 hectares will have a positive impact on water quality (863 contracted grants, using 60.7 million EUR), as neither fertilizers nor pesticides are used in forestry. Indirectly, measures to maintain forest areas also have a positive effect on water protection. Measurements 8.2.1 Establishment of agroforestry systems enable the development of coastal buffer strips and other areas to reduce surface run-off - without requiring a change of cultivation branch. Interest in the call under the measure was lower than expected.
- In the case of non-productive investments (habitat protection and water protection), non-productive investments in habitat protection can be considered successful, using the awarded support worth 3.5 million EUR in 364 projects. Nevertheless, the available budget has not been exhausted. Under this tender, important target areas were supported, which simultaneously serve to reduce the amount of applied nutrients and have a positive effect on pollutant transport processes (establishment of permanent greenery, grassland planting, hedge planting at the edges of agricultural fields, establishment of beekeeping crops). There was little interest in the call for non-productive investments in water protection, so it was less able to contribute to the results. No application was received for the call for proposals for territorial water retention (landscape management) based on cooperation. The low activity of applicants, especially in the light of the fact that the National Water Strategy gives priority to territorial water retention, is among the four sectoral objectives until 2030. To this end, the Rural Development Program launched two separate measures and identified them as eligible activities for several other measures.
  Nevertheless, these interventions need to be supported in the future while achieving the right incentive effect. In Hungary, the support of cooperative water management is highly justified, especially through partnership agreements at the river basin level (e.g., with the establishment of landscape management communities). Non-productive investments also need increased support in the future, especially in vulnerable areas and hills.
- Sustainable, modern, water-saving irrigation development in the case of arable crop production, horticulture and the planting of wine vineyards was supported by the Rural

Development Program. A total of 893 grant decisions were issued for the three calls, amounting to 90.5 million EUR. The need was about twice the amount of support awarded for all three calls.

DISCUSSION

The ex-post evaluation of the New Hungary Rural Development Program (NHRDP), 2007-2013 found that the NHRDP was only able to make a small contribution to meeting the objectives of the NRBMP1, despite the common goals. The primary reason for this was that the NHRDP was launched in 2007, while the first version of the NRBMP entered into force in 2010. The shortcomings resulting from the time lag should have been reduced by an ex-post harmonization review.

One of the main results of the RDP is that the erosion, inland water and drought sensitive areas proposed in NRBMP1 have been demarcated within the framework of the AES. Overall, it can be stated that the agri-environmental activities implemented in the AES zonal water protection target programs reached only a small percentage of the supported areas due to the low activity of applicants.

However, most of the resources are not focused on water protection risky (for water bodies with a worse than good rating) or on the water protection areas demarcated in the RDP, one of the reasons for which is that water management aspects are not given enough emphasis in the selection of tenders.

Overall, examining the period of the RDP, there is still a slight improvement in the state of the waters compared to the expectations of the EU (Water Framework Directive), despite the fact that the measures should have had a much greater impact due to their territorial extent. One of the reasons for this is that, in the case of surface water, in addition to excessive application of nutrients and pesticides, water quality is also affected by transport processes (plains, hills) and other water management interventions (e.g., inland drainage, etc.) and groundwater. its contamination depends on the transport processes taking place in the root zone and the unsaturated zone or on the nature of the groundwater management. In addition, these impact processes are often much slower than the timeframes of strategic planning, so the effects of the measures taken during the strategies cannot be demonstrated during the implementation and evaluation of the plans.

In the objectives of the AES 2014-2020, the areas to be prioritised for water protection have been clearly identified, with the delimitation of areas for water protection (extension of erosion-sensitive arable land, drought-sensitive arable land, inland water-sensitive arable land and grassland), which are not currently linked to the results of the status assessment of the NRBMP (catchment areas of water bodies with a poorer than good status).

An important conclusion indicating the lack of this is that the total area of operations supported covers 38.5% of the catchment area of surface water bodies with significant diffuse pressures (i.e. the catchment area of surface water bodies with less than good status). For groundwater, only about 50-60% of the measures currently cover water bodies with poor water quality status, and only about 10% of the areas supported by measures cover water bodies with poor status.

If the data is compared with the erosion, inland water and drought sensitive areas identified in the RDP, it can be seen that, 35% of the 981,000 hectares of supported area was in a water sensitive area. An important conclusion to be drawn from this is that if priority were given to water-critical areas, the effectiveness of the measures could be doubled or tripled.

Another problem is that the agri-environmental programmes specifically designed for water sensitive areas have not been popular with farmers (agri-environmental activities in water sensitive areas account for less than 1.5% of the supported areas). This implies that farmers prefer to apply the rules of horizontal requirements rather than certain specific requirements, so further incentives are needed to choose specific requirements.

Acknowledgments

European Union legislation, which regulates the use of the European Agricultural Fund for Rural Development (EAFRD), requires regular evaluation of the effectiveness, impact and experience of the support. In line with this, the Managing Authority of the Rural Development Programme 2014-2020 commissioned a consortium led by Field Consulting Services Zrt to prepare an evaluation report on the "Effectiveness and efficiency of interventions in water management" as part of the evaluation tasks provided for in the Programme Evaluation Plan. The present analysis has been prepared as part of this study, on the basis of data provided by the Hungarian State Treasury.

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COMPARISON OF SURVEY- AND PHOTOGRAMMETRY-BASED ELEVATION MODELS FOR A FIELD IN GÖDÖLLŐ, HUNGARY

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ABSTRACT

With the recent developments in UAV based imagery and photogrammetric methods, aerial survey can now be utilized to derive surface models for further geomorphometric processing and utilization. The purpose of the present study (conducted by students of the Agricultural Water Management MSc program at the Hungarian University of Agriculture and Life Sciences, MATE) was to evaluate the accuracy of such models and their potential for further utilization. The study was conducted at an experimental field at MATE's Szent István Campus, Gödöllő, Hungary. The resulting maps present the spatial and vertical errors resulting from the individual and combined utilization of the derived models.

Keywords: elevation model, UAV, photogrammetry

INTRODUCTION

UAV (Unmanned Aerial Vehicle) is a quickly developing part of remote sensing. UAV based imagery techniques offer different and new aspects for aerial survey. Using remote sensing techniques allow us to collect huge amounts of data from a large area in a short time and cost-effectively.

Remote sensing is the acquisition of information about an object, phenomenon or area without making physical contact with the object, in contrast to on-site observation techniques (Jensen, 2007). It is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (Bácsatyai & Márkus, 2001). Typically used apparatuses are satellites, aircrafts and drones.

Remote sensing provides a detailed overview of a AOI (Area of Interest) and has many useful opportunities in soil, land surface, water and atmospheric science (Campbell, 2006). It can be used for calculating different kinds of soil, vegetation and water indexes, creating land surface analysis such as digital elevation models (DEM). Applying UAV during the creation of a digital elevation model, offers us a quick and simple method for data collection about a specific area.

Several studies were dealing with digital elevation models in different aspects. Vertical accuracy of open source digital elevation models was examined by Mukherjee et al., 2012. Other authors were investigated the effect of digital elevation model accuracy on hydrology and geomorphology (Walker & Willgoose, 1999). The studies show the same results, the accuracy of the different DEM is highly adequate for many scientific purposes.

Another important part of land surface survey is the GIS (Geographic Information System) based approach. This technique provides an appropriate base point for simple and quick data management and analyses (Vágó et al., 2011).

GIS is a system that describes phenomena for a specific region and combined with software tools for managing, analyzing, and visualizing collected data (Allaby et al., 2008).

Within the framework of this recent work, we were focusing on a comparative study of in situ survey and UAV based elevation models. Our purpose was to perform proper data collection and create digital elevation models in both ways. However, a significant point is to evaluate the accuracy of such models and their potential for further utilization.

MATERIALS AND METHODS

The designated study area is the experimental field of Hungarian University of Agriculture and Life Sciences, a small agricultural area in Gödöllő, Hungary (Figure 1).

Figure 1. Experimental area of the University (source: Google Earth)

Precise planned data collection was the first section of the study. In the case of UAV survey, DJI Phantom 3 Standard drone has been used during the measurements. We carried out the data collection on 8th of March 2022 at 12:00. The specified flight altitude was 30 meters and a chessboard method was applied for the mapping. With reference to the flight route, that was designed by the DJI Go application.

Second significant part was the data pre-processing and creation of the digital elevation model. To perform photogrammetry related steps, we were using Agisoft PhotoScan Professional software. We had to carry out some process before we could build a digital elevation model. Image aligning was an important process because a proper geographic coordinate system is essential for the model creation. After that, the software was built a dense cloud from the collected data (captured UAV images). In the third step, high accurate orthophoto was created from the previously built dense cloud. Using the created orthophoto we could create the digital elevation model of the study area.

Another significant part of the recent study was the on-site survey. All kinds of geodesic equipment were used in the course of in-situ measurements. To build digital elevation model form the collected field data we were using QGIS 3.16.6 and SAGA GIS 2.3.2 software.

Figure 2. DIJ Phantom 3 Standard

RESULTS AND DISCUSSION

Merged orthophoto of the AOI provided a good insight with a high-resolution image about the effect of actual processes (applied different agrotechnics) on the field. The aerial photo was created from 78 separate images.

Figure 3. UAV based orthophoto of the AOI

Performing the pre-processing and model building steps, we created a digital elevation model in both ways. The data would seem to suggest that the altitude of the UAV based elevation model ranged between 260-230 meters. The results of the calculation can be seen on Figure 4.

Analysing the UAV based DEM, the lowest point (230 m) of the experimental field is situated in the north-eastern part and the highest point (245 m) is located in southwestern section of it.

UAV-based elevation values were corrected for the survey base point, after which elevation information was extracted for each survey point and than the difference was calculated. Figure 5 presents the histogram of differences between the two surveys, with values indicating the position of survey poins relative to the DEM surface. The large number of extreme errors indicate that there are significant errors within the UAV-based product, such as the effect of plants and other artifacts, or possible processign errors.

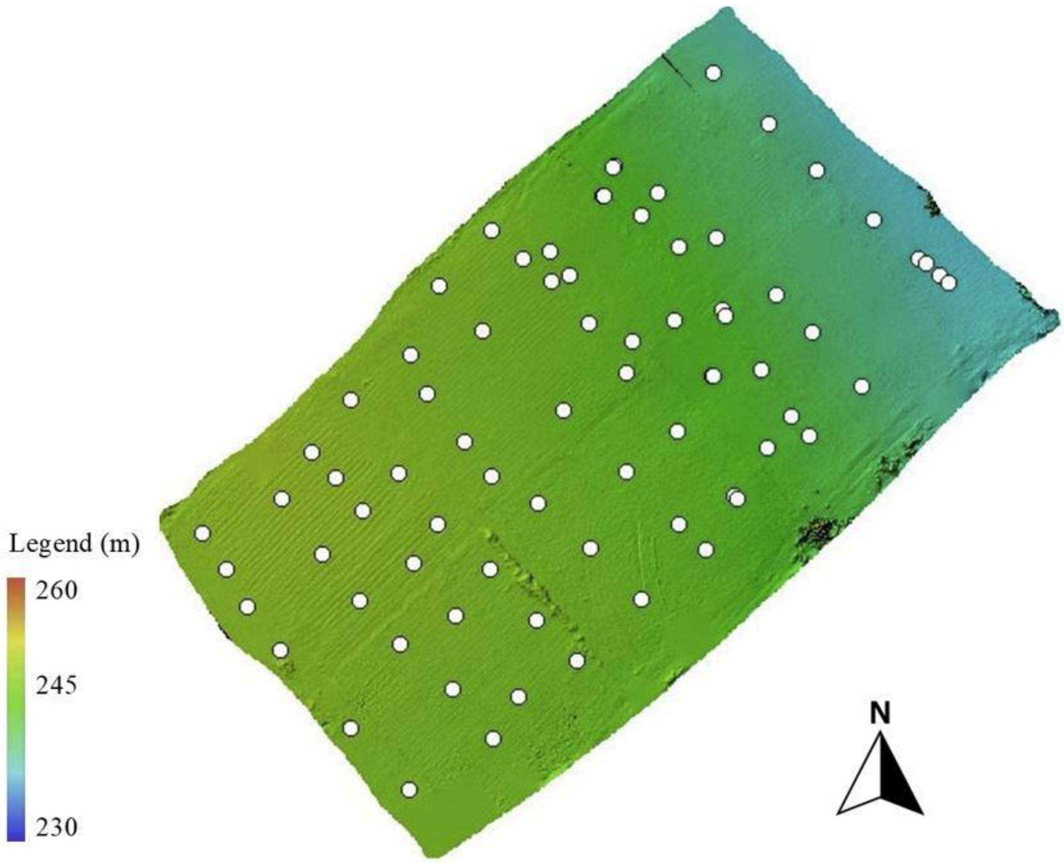

Figure 4. UAV based digital elevation model (with reference points) of the experimental field

The figure reveals that the altitude of the model ranged between 242-225 meters. After a detailed analysis, the data show that the highest point was 243 m while the lowest point was 232 m. Our results indicate that wile the photogrammetry-based raw DEM is seemingly accurate and provides a lot of detail, compared to survey-based elevation models is still carries a significant number of errors. Therefore, if such models are intended to be used for modelling purposes, further corrections must be carried out. However, a combined use of such DEMs and survey poins with the possible application of geostatistical methods might produce more reliable results.

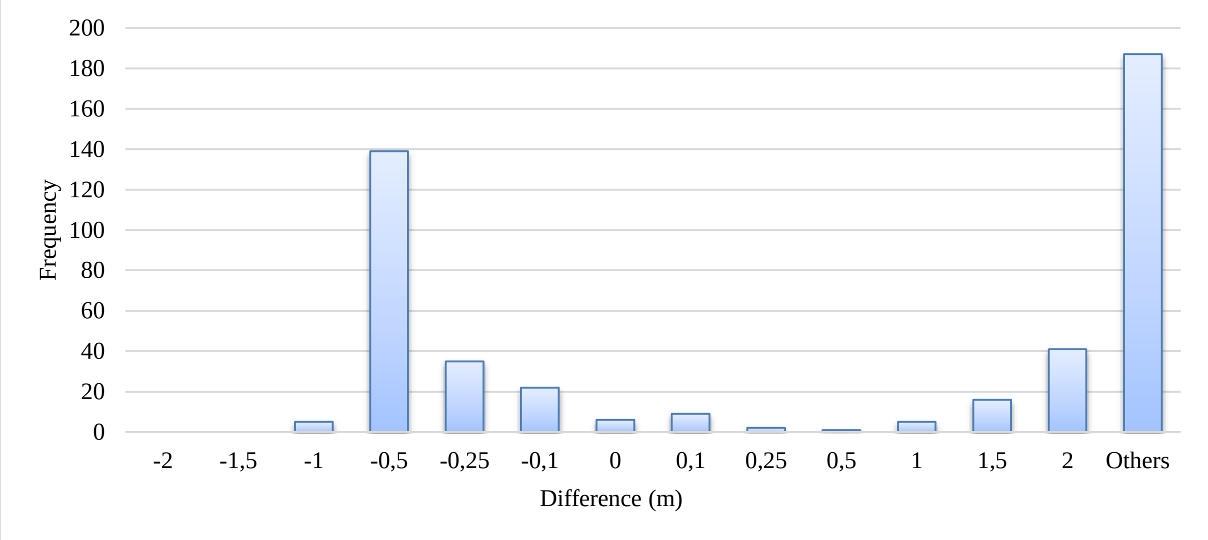

Figure 5. Histogram of elevation differences between surveys

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ROMANIAN AGRITOURISM-AN OLD AND STILL FASHIONABLE FORM OF TOURISM

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ABSTRACT

Rural tourism is actually a recent phenomenon. For many years - even decades for many European countries - it has been practiced spontaneously or organized, tourism activities at the country. What is new, however, refers to the size of the phenomenon in rural areas. Many governments and many countries agree that rural tourism activity represents a way to save first rural area with cultural heritage and then agriculture. This type of activity in rural area is in full ascension, and in time could have a positive impact on local development. There is, among the travelers, the pursuit of local touch or local experience, these two concepts which include, in fact, what has the Romanian village better preserved: authenticity and lively rural spirit. The territory of Romania presents a great variety of historical cultural values - folk art, ethnography, folklore, traditions, historical vestiges - a harmonious natural setting combined with a varied and picturesque landscape background. Owner of the last living rural civilization in Europe, Romania could become the strongest magnet for agritourism on a continental scale, rural tourism being probably the most spectacular form of tourism in Romania for the last 25 years. The reason for the development of this type of tourism is the high demand, especially in the area of domestic tourism. The closer it is to the essence, the more valuable the experience is, and the tourist appreciates and recommends it further. The recipe for success seems to be "less is more".

Keywords: agritourism, Romania, form of tourism, particularities

INTRODUCTION

Rural areas represent an area with multiple resources, but also with multiple problems to be solved. (Panyik 2011) In this context rural tourism activity, with its multiple forms of development could be a possible solution (Beeton 1999) to support future capitalization, and finally future development (Adamov 2006). Rural tourism, in recent times, has a strong evolution and enjoys greater attention, because the authenticity of rural areas is an advantage and in the same times a demand from the peoples. Many authorities from Europe and from the world must recognize that tourism in rural areas represents a healthy alternative both for peoples from urban area and for agricultural activities from rural areas. Taking in consideration the mentioned aspects it can be said that "in next 20 years tourism will be a component of the rural economy, and rural tourism can become tourism of the future".

European Union countries have also directly involved in agritourism, by building holiday homes or by restoring and upgrading existing ones. This action is specific to France and Portugal and has been done with the support of local authorities. Thus, many abandoned houses were reintroduced into the sphere of agritourism, transformed into modern agritourist farms rented to tourists during different periods, this paying a community tax. All states have paid particular attention to the use, conservation and sustainable development of the environment. Have been signed protocols to take responsibility for protecting and enhancing the environment, setting up abandoned areas, taking care of adjacent spaces. Owners assume written responsibilities for environmental care and conservation. In this context tourism in rural areas, particularly agritourism can and will be a solution to many problems.

Romanian agritourism is an important means of tourist attraction represented by a wide and diversified range: decorative fabrics, folk costumes, wood and stone sculptures, painting on glass or wood, egg painting, wickerwork and also folk music and dances. Romanian alerts and well-paced. But what gives it the leading place in the country's tourist heritage are the landscapes: impressive, fairytale lace in karst forms from the limestone regions, circuses and glacial valleys, bare peaks, unique or strange shapes of the rocks.

MATERIALS AND METHODS

This present research aim to bring in light rural tourism/agritourism as a particular form of tourism to suport Romanian rural areas development. The objectives pursued in the paper follow: the characteristics of agritourism, first agritourism initiatives in Romania, aspects concerning tourist guesthouse, social dimension of this type of activity. In order to implement the research proposed the authors have used case study method, and follow several steps: data collection, processing, analysis, observation and their interpretation.

RESULTS

The territory of Romania presents a great variety of historical cultural values - folk art, ethnography, folklore, traditions, and historical vestiges - a harmonious natural setting combined with a varied and picturesque landscape background. All these are valences of the Romanian rural tourism in particular. Due to the richness and beauty of the plateau areas, they are well populated, and the traditions, folk customs passed down from generation to generation, as well as the legends and stories of the locals are as many attractions along with wines, spirits or traditional gastronomic which who had the chance to know, cannot resist.

The elements that need to be highlighted are:

- recreational, aesthetic and landscape value, not infrequently determined by the choice of destination (mountain, hill, plain, seaside or delta);
- the curative value (balneoclimateric) of the bioclimate or of the natural factors of the area;
- the setting for some moments of relaxation or some hobbies (water mirrors, mountain massifs, caves, torrents, hunting resources, snow cover, etc.);
- cognitive value in the case of components designated as parks, botanical or zoological gardens, scientific reservations or natural monuments.

With what comes new and relevant agritourism field, as an impact (Călina 2017) on the rural environment? Agritourism is a component of tourism, and has mainly the following characteristics: (Ciolac 2009, Ghereș 2003)

a. - has a high degree of complexity;

- represents an economic activity that capitalizes on the surplus of accommodation spaces existing in the peasant household;

- offers tourist services (accommodation, boarding house, leisure);

b. - the owner carries out, in parallel, activities with an agricultural profile (cultivating plants, raising animals, etc.);

c. - tourists are offered the opportunity, for recreation purposes, to participate in household activities (drying hay, harvesting fruit, milking cows, fishing, processing agricultural products, preparing food);

d. - has a determined duration of time (summer or winter holidays, weekends);
e. - has different purposes: recreation, introduction to the art of traditional crafts, studies and documentaries;
f. - as a rule, it represents a secondary activity, the agricultural activity in one's own household remaining the main occupation and source of income;
g. - constitutes a means of integral capitalization of the rural area with its natural, agricultural, economic, tourist, cultural, socio-human potential (Adamov 2016);
h. - contributes to the sustainable development of the rural area, (Glăvan 2003, Mitrache 1996) by: maintaining the ecological balance; sustainable use of tourist resources; maintaining the natural, cultural, ethnographic, social diversity, etc., favors the development of the communication, urban infrastructure, etc.; favors the economic development of rural localities; the tourist benefits from an unpolluted, ecological environment; the tourist has access to natural tourist attractions, free of stress factors; the ambiance encountered by the tourist is familiar, with a strong hospitable character; allows the realization of a tourism adequate to the different categories of age or social status: elderly people, people with disabilities, families with small children; married young people etc.
i. - the tourist has access to traditional holiday menus, specific to different geographical areas;
j. - agritourism is carried out in close correlation with the local economy and train a multitude of other local fields;
k. - close correlation especially with agricultural branches.

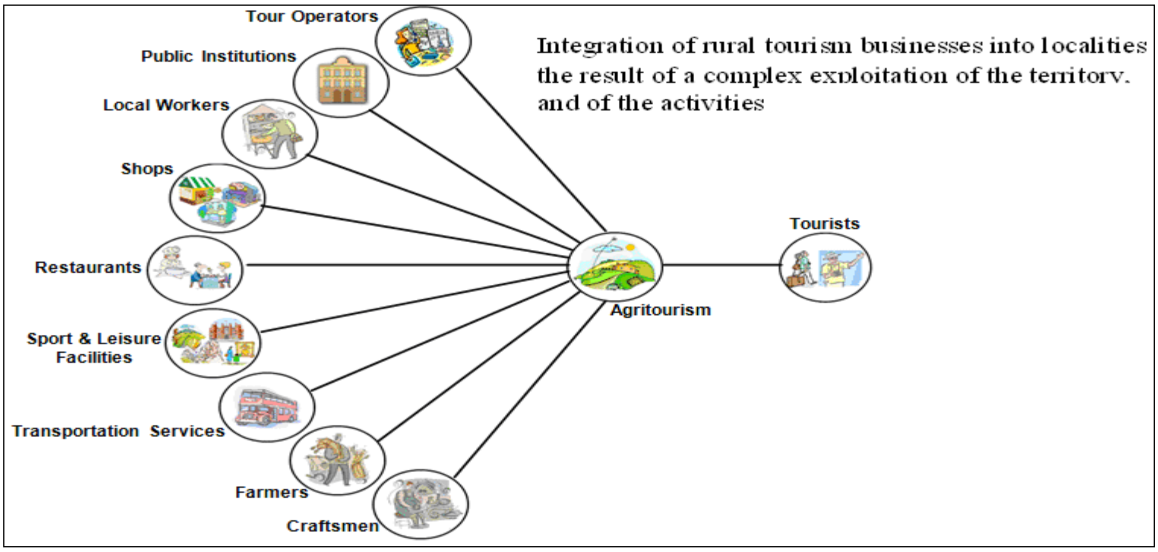

Figure 1. Agritourism integration at community level

The first agritourism initiatives in Romania are closely related to spa tourism. In the 1930s, the population who came for treatment in various areas where there were hot springs, sought accommodation even with the locals of the surrounding villages. This hospitality sector has evolved a lot since then, but not everyone who practices it respects the framework in which it should take place, and not necessarily through their own fault.

First of all, agritourism must be defined as rural, but in rural Romania there are only communes, and many of the important destinations of agritourism have been declared cities, such as Horezu, Voronet, Tismana, Rasnov, etc. Also, agritourism involves low-capacity buildings, which are usually of architectural interest, being decorated in a rustic style, reminiscent of traditional homes. In this context, special attention is paid to traditional local cuisine and, most of the time; they are run in a family system.

The tourist guesthouse, according to the standards imposed by the Ministry of Tourism, comprises a maximum of 15 rooms and no more than 40 places. Regarding the limitation of places, this was done at the proposal of the ANTREC association, because the rooms have many beds and it is possible to reach an impermissibly large number of places, so that the location no longer resembles of guesthouse.

However, in recent years the comfort of the boarding houses has greatly increased, most of the rooms have a bathroom with central heating, the courtyards are decorated in a rustic style, with swings, kiosks, barbecues, flowers, and the gastronomic offer respects the traditional, both in terms of menu and presentation. Also, internet access is present in almost all locations, and not because it should have been part of the landscape, but because there was a high demand and the need has taught the locals to improve their services.



What is also gratifying is the fact that the activities offered have improved, both at the level of the guesthouse - a ping-pong table, a basketball hoop, free or paid bicycles, and at the level of the locality or area - bicycle rental, indoor swimming pools, horse riding. At least five riding centers have appeared in Rasnov, a relatively small area. Dissatisfaction remains regarding the existence of houses and guesthouses that do not respect the style of the area at all.

Even if few locals realize the benefits that these organized events can bring to the villages, because many contribute to their realization out of a national pride or, in other words, local patriotism, in a positive sense, these benefits are real. For example, the village of Ciocanesti in the Bistrita Valley has risen as a tourist destination with the help of events. It all started with the Trout Festival organized by the members of the Antrec Bucovina Association, in 2004. It also included gastronomy, painted pottery, etc., being made with the help of the mayor of that time. In fact, it is very important to involve local authorities in the success of promoting a destination, both financially and for the fact that they can give their consent in the use of public areas where events take place - parks, pastures. The Oituz Festival, in which six or seven villages participate, is again very well done, with a historical load, with absolutely special landscapes, being organized by Antrec Bacau. This event is attended by locals and people from other areas, such as members of Antrec Alba, who are very active, both at home and in other areas. In Gorj, also, the Cold Festival is again one of success and longevity, being this year at the tenth edition.

Surprisingly, a large proportion of young people are consumers of agritourism. For example, an area that has developed a lot with the help of the young tourist is the Danube Boilers, the offer of boats, bicycles, hiking being an attraction for them. Another area, of the same category, would be the north of Oltenia, on the Sohodol Gorges, where there is a rafting offer. In fact, it can be said that there where are activities, there are also young people. Otherwise, the consumer of agritourism is generally intellectual, who goes to spend time in a very quiet area. As areas, the most wanted remain Bran, Moeciu and Rasnov, which have developed a lot lately. For foreigners, Bucovina, Maramures and Sibiu remained, and as newcomers, Clisura Dunarii, Mehedinti, Buzau-Vrancea, northern Oltenia. If in the past years most tourists chose to stay for a weekend, in the last period, many tourists also opted for stays of 5-7 nights in guesthouses. The reasons are both the high quality of the services and their personalization, as well as the high security and the natural environment. On the other hand, some tourists have replaced stays at large hotels, in the mountains, at the seaside or in spas with stays at rural guesthouses. In general, the guesthouses recognized for the quality of services were chosen.

Besides being fashionable, tourism in rural areas also has an important social dimension, due to its lower prices and specifics, mostly family tourism, and youth tourism, has some specific trends illustrated in the chart below:

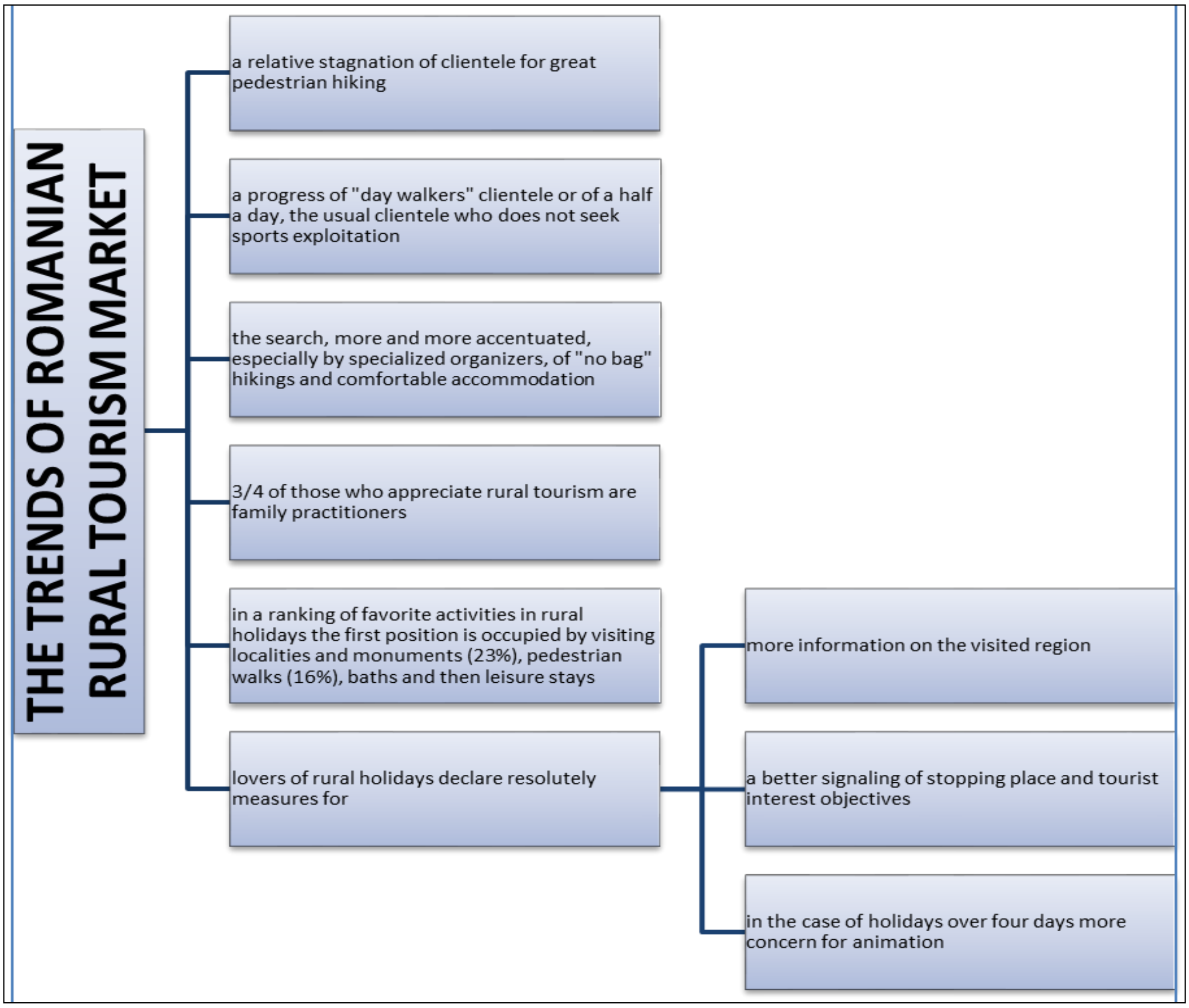

Figure 2. Trends of Romanian rural tourist market

- a relative stagnation of clientele for great pedestrian hiking;
- a progress of "day walkers" clientele or of a half a day, the usual clientele who does not seek sports exploitation;
- the search, of a comfortable accommodation;
- most part of tourists from agritourism activity is represented by families;

The guesthouses are divided into two categories, namely tourist ones and agritourism, which have in addition the activity given by their own farm and which is a factor of interest (Ciolac 2019) both in terms of food and for tourists and their children, who can take part in activities with the owners.

Guesthouses from Romania-Particularities	**Types of guesthouses**	75% houses of the locals
		25% houses built especially for tourism rural
	Who are the owners	80% locals
		20% inhabitants of the city
	Guesthouses capacity	Small (1-3 rooms) – 20%
		Medium (3-6 rooms) – 30%
		Large (7-10 rooms) – 30%
		For groups (10-15 rooms) – 20%
	Location depending on the relief	65% located in mountainous regions
		35% located in other parts of the country
	Location	75% in the villages
		20% in small towns (former villages)
		5% in villages located in the suburbs of big cities

Figure 3. Guesthouses from Romania-Particularities

Owner of the last living rural civilization from Europe, Romania could become the strongest magnet for agritourism on a continental scale, if it had the intelligence to authorize at least 100,000 peasant farms of rural tourism type (rooms for rent). What could Romanian village offer to foreigners, an offer that does not exist in other European countries?

- Over 3 million peasant farms that practice environmentally friendly agriculture;
- Over 3 million peasant farms with a unique gastronomic heritage;
- Over 3 million peasant farms with an authentic traditional heritage;
- Over 3 million peasant farms with a total of approx. 5 million free rooms;
- Over 2 million young peasants who could return in the village if they could see an economic future in their parents' home;

What agritourism services can the peasant farm offer?

- Classic agritourism services: On-farm tastings; Participation in agricultural activities; Participation in meal preparation; Fishing; Hunting, etc.
- Classic rural tourism services: Camping in tents and caravans; Guest rooms; Half or full board etc.
- Barter services "tourist offer" managed by international networks: beds barter or houses or whole or part of guesthouses; exchange of means of transport; barter of recreational means (boats); barter of social networks of peasant friends; barter of networks of peasant neighbors;
- Agro-cultural services: the road of wooden churches; the wine road; the cheese road; buffalo road; traditional weddings, etc.

DISCUSSION

The current rural tourism is an active presence for over 207 localities and in over 1075 households, especially from the mountainous and pre-mountainous area of Romania, but not only. Thus, especially for the months of July-August and to a lesser extent in the winter season, many of our villages receive tourists, who arrive here to spend their free time. The culture is included indirectly in the mix of the agritourism product, due to the possibilities of knowledge that it offers. Reference is made to the general knowledge of geography, history, folklore, the traditions and customs with which tourists will come into contact, as well as the exchange of information on indigenous dishes and products, the crafts and facilities they will be able to admire at the source. From this point of view, agritourism can also be an act of culture. The concept of agritourism in this context is limited to the household, or farm. It therefore consists in organizing the activities of receiving tourists and all tourist services at the level of the agricultural unit. For this reason, agritourism is generally considered to be a complementary agricultural activity.

The trend, in recent years, worldwide, is focused on the search for authentic experiences by tourists, on contact with nature, with the traditions and customs of areas kept untouched by the technological revolution. There is, among the travelers, the pursuit of local touch or local experience, these two concepts that include, in fact, what the Romanian village has better preserved: authenticity and lively rural spirit. In this context, the growth potential of this segment is very high. Rural tourism is probably the most spectacular form of tourism in Romania for the last 25 years. Romania is very well positioned at the international level, in terms of agritourism and rural tourism, which is why rural tourism is one of the forms of tourism with which we can compete with any tourist developed European country.

Agritourism does not only take shape in Transylvania, Moldova, Bucovina, Maramures, Tulcea and in some places Oltenia are other regions that are developing in a fast rhythm in recent years. The reason for the development is the high demand, especially in the area of domestic tourism, for experiences lost in childhood, experiences that Romanians could call, generically, "in search of childhood spent on grandma on the street". This segment has spectacular grown in recent years and because investments in guesthouses are not as large as those in hotels. Moreover, this area is growing with the existing resources - this is what gives it authenticity. The closer it is to the essence, the more valuable the experience, and the tourist appreciates and recommends it further. The recipe for success seems to be ”less is more”. You don't have to bother building a palace, in an area where small and chic houses would look better, as happens in the communes of Teleorman, for example. People are not looking for asphalt, insulated windows and technology in a village forgotten by the world. The business must be built in the villages, as close as possible to the geographical areas that offer tourism. The gastronomy must be kept as close to authentic as possible, and access to technology must be kept to a minimum. If to all this you add the interaction with old habits and why not with forgotten trades, kept only in certain areas, then you have the secret of a successful business.

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THE IMPACT OF THE COVID-19 PANDEMIC ON ROMANIAN TOURISM

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ABSTRACT

In this paper, the authors try to assess as accurately as possible the effects of the Covod-19 pandemic on Romanian tourism. In Romania, the first cases of coronavirus appeared on February 26, 2020, therefore the country's president signed, on March 16, 2020, the Decree on establishing a state of emergency for 30 days. Measures taken in a state of emergency and alert, ie temporary closure of hotels, cafes, restaurants and banning or restricting the movement of people to certain countries or areas, in an attempt to stop the spread of coronavirus, have had a disastrous impact on tourism and hotel industry, drastically reducing tourist flows, while also causing a significant reduction in revenue for all tourism operators, as can be seen in this article.

Keywords: tourism, hotel industry, COVID-19 pandemic, Romania, tourist units

INTRODUCTION

The outbreak of coronavirus began in China on December 12, 2019, in downtown Wuhan, Hubei Province, when people developed pneumonia without a clear cause and for which the existing vaccines or treatments were not effective.

COVID-19 is a disease caused by the virus called severe acute respiratory syndrome coronavirus (SARS-CoV-2). SARS-CoV-2 is a new strain of coronavirus that was not detected in humans until December 2019. (https://vaccination-info.eu/ro/covid-19/informatii-despre-covid-19)

The virus, called SARS-CoV-2, is transmitted from person to person throughexpelled aerosol droplets when an affected individual coughs or sneezes in an area of about 1.83 m, which can contaminate surfaces such as door handles or railings. Coronavirus drops remain suspended in theair only for a short time, but can remain viable and contagious on surfaces for up to 9 days.

The rate of infection escalated in mid-January 2020, with an incubation period (until the on set of symptoms) of about 2 weeks, when fever, cough and difficulty breathing occur.

On March 11, 2020, the WHO stated that the autbreak of coronavirus had become a *pandemic*,because it has spread to most Chinese provinces and mos tcountries in the world.

The first cases of coronavirus in Romania appeared in February 2020, and in March 2020, the country's president signed Decree on establishing a state of emergency for 30 days.

Measures taken in a state of emergency and alert, namely, the temporary closure of restaurants, hotels, cafes, clubs or restricting/banning the movement of people to certainareas, stopping ground, underground, air, naval transport, in an attemptto stop the spread of coronavirus, have had a catastrophic impact on tourism and the hotel industry.

There fore, we can say with certainty that the coronavirus pandemic took everyone by surprise, and the vacation and travel plans were shattered by the restrictions imposed by the authorities and the installed fear. This was followed by a 60% collapse in world tourism in the first six months of the year. In 2019, travel and tourism were some of the most important sectors of the world economy, almost 10% of global GDP, with over 320 million jobs worldwide and a value of nine trillion dollars. (https://romania.europalibera.org/a/covid-19-frica-restrictii-visuri-amanate-cu-cat-sa-prabusit-turismul-cat-timp-va-dura-revenirea-la-normalitate/31025202. html). The hospitality sector (HoReCa), an important pillar of the Romanian economy, which contributes almost 5% to the gross domestic product and provides more than 4% of all employees with individual employment contracts, is one of the areas that have been and continue to be severely affected by the COVID-19 pandemic. The measures taken by the state in support of this sector last year were welcomed.

MATERIALS AND METHODS

In this article, the authors used as methods of work, analysis and comparison. The data were obtained from various sources, such as: from the National Institute of Statistics and various sites. With the help of the data provided by INS, we were able to make this article and make a comparison between 2020, the year of the onset of the coronavirus pandemic, and the post-pandemic years.

RESULTS

The tourism crisis was unprecedented in 2020 and endangered almost 120 million jobs. It was felt by almost every citizen who planned a vacation or a city break this year, regardless of the area in which he wanted to travel. The travel intentions of January or February 2020 have been radically changed by the outbreak of the coronavirus epidemic, and its effects have been fully seen on tourism.

Tourism is one of the most affected sectors in the world, due to the restrictions imposed during the COVID pandemic, but also the reluctance of consumers to travel. Romania is no exception. (https://www.agerpres.ro/economic-intern/2020/12/27/retrospectiva-2020-turism-in-pandemie-vacante-anulate-afaceri-in-scadere-si-pachete-adaptate-vremurilor--634216)

The effects of the pandemic on Romanian tourism can be seen in the statistics, as can be seen in Table 1.

Arrivals registered in the tourist reception structures increased from 2015 to 2019, and in 2020, due to the pandemic, they decreased drastically, as can be seen in the table above. by 68% in 2020 compared to 2019, at 6,398,642 arrival.

The COVID-19 crisis has also led to changes in travel trends. With airports closed and forced to quarantine if they choose certain destinations, people have shifted their attention to domestic travel, to outdoor and outdoor destinations. These were considered to be of lower risk than those in large urban areas or crowded beaches.

Therefore, the mountain resorts, the Danube Delta or the seaside have become targets for Romanian tourists who prefer to go abroad. Also, other less known destinations have become of interest for Romanian tourists, such as: Călimănești, Căciulata or Geogiu-Băi.

The same trend can be observed in terms of the number of tourists arriving in our country (Table 2).

Table 1. Arrivals of tourists in tourist reception structuresin the period 2015-2020 (number)

Specification	2015	2016	2017	2018	2019	2020
Total	**9921874**	**11002522**	**12143346**	**12905131**	**13374943**	**6398642**
Hotels	7214613	7927540	8565979	9004486	9274954	4116681
Hostels	258106	317027	374806	383696	393038	175049
Apartment hotels	59249	45621	58804	62295	77285	55577
Motels	259961	264086	251047	268310	276928	143308
Inns	1994	3409	3928	2630	2911	759
Tourist villas	291540	327824	409165	440497	463600	267338
Tourist chalets	94976	117304	136832	144182	153374	95370
Bungalows	24491	26483	32196	40538	40370	36464
Holiday villages	5932	4588	6233	4841	6341	2987
Camp grounds	60723	52043	49484	38519	60341	50982
Tourist stops	17772	21082	31014	30530	25152	15464
Tourist houses	11798	14364	12100	16350	20556	20086
Camps for students and preschoolers	48109	46468	48213	54731	46949	3302
Tourist pensions	899494	1020606	1157665	1234295	1254476	654397
Agrotourism pensions	672756	813454	1004400	1173455	1272878	755436
Accommodation on river and seavessels	360	623	1480	5776	5790	5442

Source: https://insse.ro/cms/

Table 2. Arrivals of tourists in tourist reception structures with tourist accommodation functions, by types of tourists,in the period 2015-2020 (number of people)

Specification	2015	2016	2017	2018	2019	2020
Total	**9921874**	**11002522**	**12143346**	**12905131**	**13374943**	**6398642**
Romanian	7681896	8521698	9383266	10108509	10691195	5944775
Foreigners	2239978	2480824	2760080	2796622	2683748	453867

Source: https://insse.ro/cms/

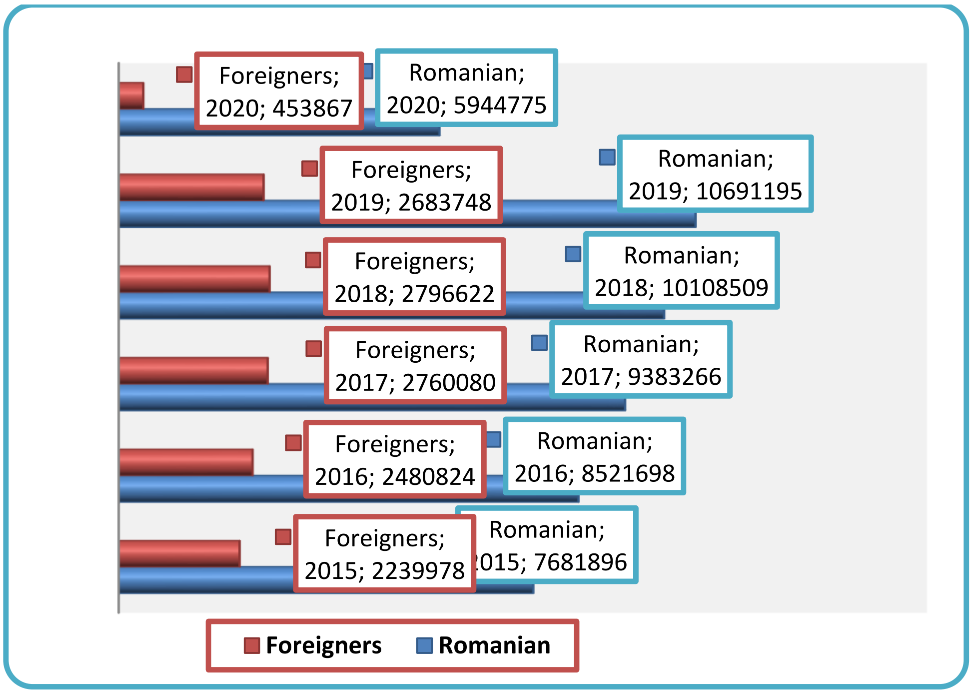

Figure 1. Arrivals of tourists in tourist reception structures with tourist accommodation functions, by types of tourists, in the period 2015-2020
Source: https://insse.ro/cms/

The arrivals registered in the tourist receptions tructures in the period analyzed by us had an increasing trend until 2020, when the pandemic appeared, but in the first half of 2021 they increased 52.4% compared to the same period last year, show data from the National Institute of Statistics. The arrivals of foreign tourists who visite dour country collapsed, they represented only 6% of the total.

Out of the total number of arrivals, between January 1 and June 30, 2021, the arrivals of Romanian tourists in the tourist reception structures with accommodation functions represented 94%, while the foreign tourists registered a percentage of only 6%. Regarding the arrivals of foreign tourists in the tourist reception structures, the largest share was held by those arriving from Europe (81% of the total foreign tourists), and of these, 72.7% come from European Union countries, such as: Germany, Italy, Israel, the United Kingdom and France. (https://www.digi24.ro/magazin/timp-liber/vacante/pandemia-a-prabusit-turismul-romanesc-cu-cat-a-scazut-numarul-turistilor-fata-de-anul-trecut-1361864)

By counties, in the first half of the year, the number of tourist arrivals in the tourist reception structures with tourist accommodation functions registered higher values in: Braşov (424,600 people), Bucharest (326,900 people), Constanța (198,900 people), Prahova (176,400 people), Bihor (169,700 people).

From our research, we can say with certainty that the pandemic did not completely destroy Romanians' appetite for holidays abroad, so with the partial lifting of restrictions in European countries, Romanians packed their bags and went to destinations such as : Bulgaria, Greece and Turkey, which remained this year in the top of Romanians' preferences as destinations. (https://economedia.ro/cum-a-evoluat-piata-turismului-din-romania-in-prima-jumatate-a-anului-sosirile-turistilor-au-crescut-cu-52-gradul-de-occupare- of-accommodation-is-still-down-hundreds-of-units-were-locked-in.html # .YjOvzXpBxPY, Băneş Adrian et al, 2021; Dincu Ana-Mariana et al. 2016; Dincu Ana-Mariana et al. 2017; Sicoe Caius et al., 2021)

The overnight stays registered in the tourist receptions tructures in the first six months of the year amounted to 6556.6 thousand, increasingby 53.2% compared to those from January 1 to June 30, 2020. Out of the total number of overnight stays, the overnight stays of Romanian tourists in the structures of tourist reception with accommodation functions accounted for 93.2%. Regarding the over night stays of foreign tourists in the tourist reception structures, the largest share was held by those arriving from Europe (81.4% of the total foreign tourists).

The average length of stay in the first six months of the year was 2 days for Romanian tourists and 2.3 days for foreign tourists.

The index of net use of tourist accommodation places between January 1 and June 30 was 19.2% of total tourist accommodation structures, decreasing by 0.2 percentage points compared to the period January 1 - June 30, 2020. net use of larger tourist accommodation, between 1.01.-30.06.2021, were registered in hotels (22.8%), accommodation on ships (21.9%), tourist villas (17.3 %), bungalows (15.3%), tourist pensions (14.6%), tourist chalets (14.1%), tourist stops (13.8%), agritourism pensions (13.7%), tourist cottages (13.0%) and hostels (12.9%). (Dincu Ana-Mariana, 2015;)

The means of road and air transport were the most used for the arrivals of foreign visitors in Romania, representing 85.0% by road and 10.9% by air, respectively, out of the total number of arrivals.

The hotel market was, without a doubt, one of the most affected by the COVID-19 pandemic and is expected to fully recover, in this context, by 2024. (https://jurnaluldeafaceri.ro/turismul-in-romania-mai-2021/)

Since the beginning of the pandemic, the Romanian state has granted certain aids or fiscal facilities to the taxpayers from the HoReCa industry, but with in the limits of the budgetary space and in the conditions in which other sectors also needed support.

(https://www2.deloitte.com/ro/ro/pages/tax/articles/un-an-de-pandemie-in-horeca-masuri-de-sposten-luate-in-romania-si-in-alte- tari-europene.html)

HoReCa taxpayers can now access the state aid scheme, which involves providing financial support to tourism businesses, accommodation facilities, catering establishments and travel agencies whose activity has been affected in the context of the COVID-19 pandemic.

DISCUSSION

The hospitality sector (HoReCa), an important pillar of the Romanian economy, which contributes almost 5% to the gross domestic product and provides more than 4% of all employees with individual employment contracts, is one of the areas that have been and continue to be severely affected by the COVID-19 pandemic.

In the hotel and restaurant sector, catering, the impact of the pandemic is controlled by business uncertainty, either the closure of the business or a reduction of more than 50% of the volume of business.

It is very possible that the pandemic has helped to raise tourists' awareness of travel insurance, so in the long run thereis a good chance that insurance will be part of tourism marketing strategies.

Many travel companies have already begun to offer more flexibility for both existing and new bookings, which is likely to resonate with about a quarter of tourists.

Domestic tourism has been the main attraction this year, given the pandemic context, and most tourists have chosen destinations on the coast, in the mountains or in spas.

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ASPECTS REGARDING THE TRADING OF WHEAT ON THE ROMANIAN GOODS EXCHANGE IN 2021

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ABSTRACT

In our country, the Romanian Commodity Exchange (Joint Stock Company) operates as a financial investment company, its purpose being to offer practical solutions in the field, in a transparent, efficient and professional way. The situation on the cereals market, both nationally and internationally, influences the volume of transactions and the level of quotations (and) on the Romanian Commodity Exchange. In the paper we analyzed the level of quotations established for wheat, during 2021. The final conclusion that emerges from the analysis of existing price levels indicates that the price of wheat is rising.

Keywords: wheat, production, areas, quotations, commodity exchange

INTRODUCTION

The important link of the market economy, the commodity exchange is an institution organized and supervised by the state, through which commercial exchanges (transactions) with goods are carried out, without the presentation, delivery and simultaneous payment of the object of the transaction.

The commodity exchange is the market where quality, substitutable fungible goods are traded, substitutable, according to a special procedure that takes place, based on a program, in a known place, in the presence of buyers or their representatives, under the supervision of authorities. The negotiation is not carried out on physical goods, individualized and present as such at the place of contracting, but on the basis of representative documents ("papers"), which enshrine the ownership of the goods and constitute its commercial image (a certain amount of goods Therefore, the commodity exchange is a dematerialized market where the contract between the parties is concluded, the identification and circulation of goods being carried out outside this market.

MATERIALS AND METHODS

In order to have a correct image on the situation on the Romanian wheat market, we analyzed the following aspects:

- analysis of the main indicators related to wheat supply (cultivated areas, total and average production, average market price, export / import balance), for the period 2018-2021;
- short presentation of the Romanian Commodity Exchange(RCE) ;
- the evolution of the quotations within the RCE for the wheat support asset in 2021.

RESULTS

The volume of transactions within the RCE for the wheat product is related to the wheat market influenced by the evolution of cultivated areas, wheat production and average production per hectare.

The analysis of the evolution of the cultivated areas with wheat in the period 2018-2021, in Romania, highlights the following aspects: the cultivated area with wheat was slightly oscillating, being maximum in 2019 -2,168.3 thousand ha. We are traditional wheat growers and we are one of the world's leading exporters.

Table 1. Area cultivated with wheat

	2018	2019	2020	2021*
Area (Thousand ha)	2.116.1	2.168.3	2.088.1	2.145.7

* Ministry of Agriculture and Rural Development *-operational date (August 16, 2021)*
Source: INS 2018-2021 data, www.tempoonline

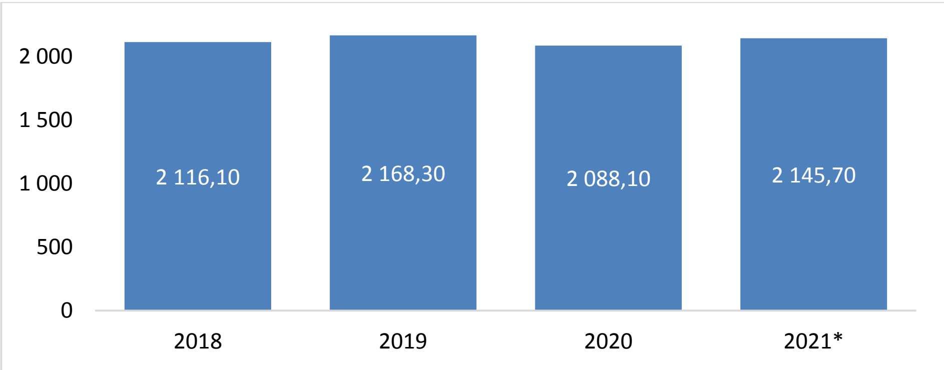

Figure 1. Agricultural land used for wheat farming (thousand hectares)

According to the operational data of Ministry of Agriculture and Rural Development , the total wheat production harvested in 2021 was 11.33 million tons, being the highest production recorded since Romania's accession to the European Union.

Table 2. Wheat production

	UM	2018	2019	2020	2021*
Wheat production	thousand tonnes	10.143.6	10.297.1	6410.9	11.331.8

* Ministry of Agriculture and Rural Development *-operational date (August 16, 2021)*
Source: INS 2018-2021 data, www.tempoonline

The analysis of the average production per hectare highlights the fact that in the interval considered the highest average production per hectare was recorded in 2021 -5,346 kg / ha, production due to both favorable weather conditions for this crop and changes in crop technologies and the emergence of high-performance equipment in many commercial farms. In 2021, 13 counties exceeded the national average, including three counties in the west of the country - Bihor, Arad and Timiș.

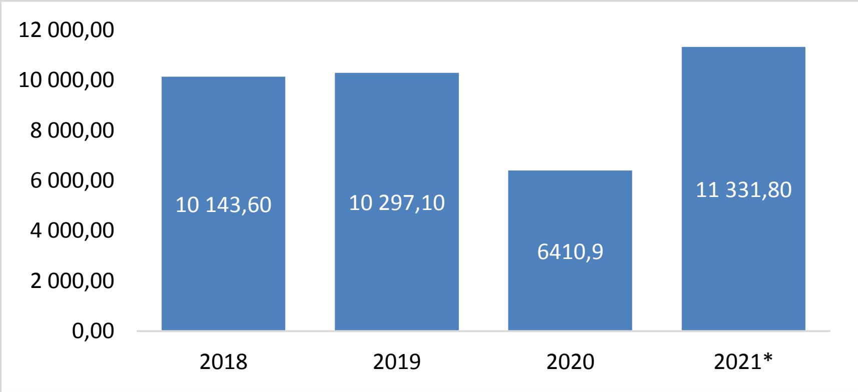

Figure 2. Total wheat production (thousand tonnes)

Table 3. Average wheat production

	UM	2018	2019	2020	2021*
Average production	Kg/ha	4793	4749	2987	5.346

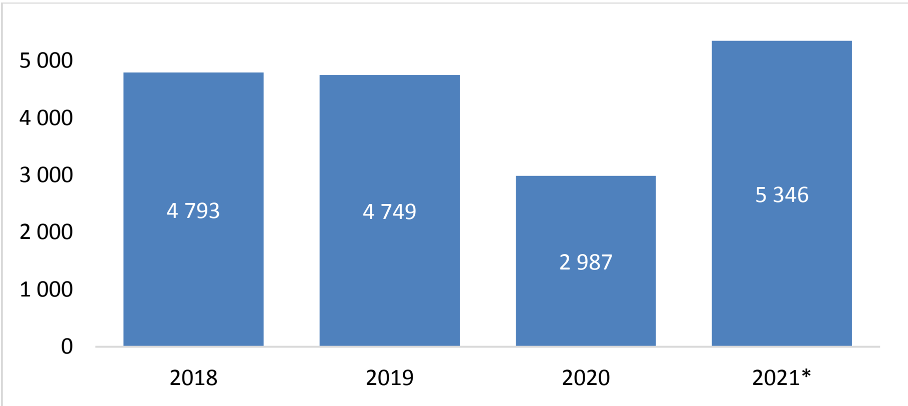

Figure 3. Average wheat yield (kilograms/hectares)

* Ministry of Agriculture and Rural Development *-operational date (August 16, 2021)*

Source: INS 2018-2021 data, www.tempoonline

The demand for the wheat product can also be analyzed in terms of its price, given by the demand / supply ratio. Until 2017, most of the wheat production was sold at harvest, so the price was one of the season. Its evolution in the period 2018-2021 was as follows:

After 2017, numerous private investments in grain depots were completed (in the territory but also in the port of Constanța), which led to an increase in the average price on the domestic market and a relatively constant price level during the year.

Regarding the import / export balance of wheat, it can be seen that in terms of exported quantities they are high in the period 2018-2021 demonstrating the capacity of our country as a strong, traditional exporter of cereals (especially wheat). Imports of grain are much lower in terms of quantity and value.

Table 4. Average domestic price of wheat (lei / kg)

Anul	Preț mediu*
2018	0,71
2019	0,73
2020	0,79
2021	0,79
2022	0,80**

Source: * Ministry of Agriculture and Rural Development operational data
** Provisional Ministry of Agriculture and Rural Development data

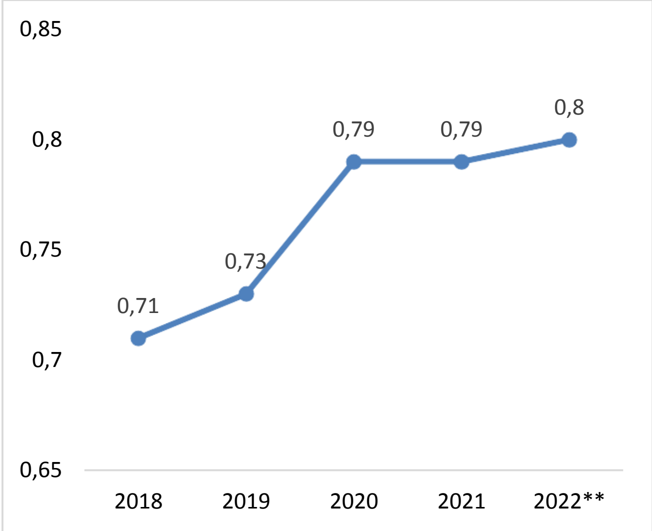

Figure 4. Average prices of wheat traded in the Romanian market (lei/kg)

Table 5. The situation regarding intra and extra-community trade in wheat in the period 2018-2021

year	Amount IMPORTED (tons)	IMPORTS value (thousand euro)	Amount EXPORTED (tons)	EXPORTS value (thousand euro)
2018	695.173.2	115.544.7	5.886.755.9	1.037.727.8
2019	880.289.4	158.501.8	6.186.776.8	1.134.732.7
2020	1.225.633.8	220.532.8	4.336.745.6	844.284.3

Sursa: * Ministry of Agriculture and Rural Development operational data, www.tempoonline

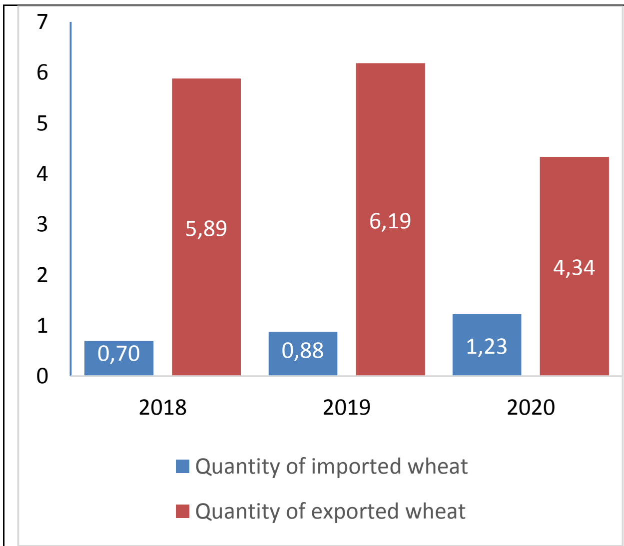

Figure 5a. Imports and exports of wheat (million tonnes, 2018-2020)

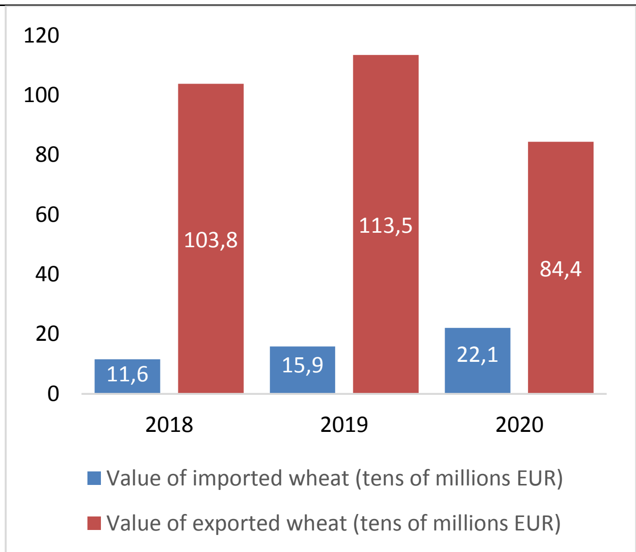

Figure 5b. Imports and exports of wheat (tens of millions EUR, 2018-2020)

The aspects that appear on the wheat market also influence the transactions that are registered on the commodity exchanges. The Romanian Commodity Exchange is organized on the model of joint stock companies, following the model of the world's major stock exchanges and benefits from a hierarchically functional system, which ensures the development of the decision-making and operational process.

Figure 6. Advantages of trading at RCE Source: https://www.brm.ro/misiune-si-valor

The terminals of the Romanian Commodity Exchange have the status of working points in the territory, managed by entities with legal personality, which have all the logistics and human capital necessary to carry out the stock exchange activity in optimal conditions.

Romanian Commodity Exchange S.A. it is organized as an available market, where goods with a high degree of standardization are traded, generically determined goods that can be replaced with each other in the execution of a contractual obligation. Regardless of their manufacturer, the goods are identified on the basis of characteristics of a physico-chemical nature, characteristics that determine their quality. Thus, the products are divided into several quality classes, depending on which their price is formed. Due to the high degree of standardization, batches of the same product that fall into the same quality class are interchangeable.(www.brm.ro)

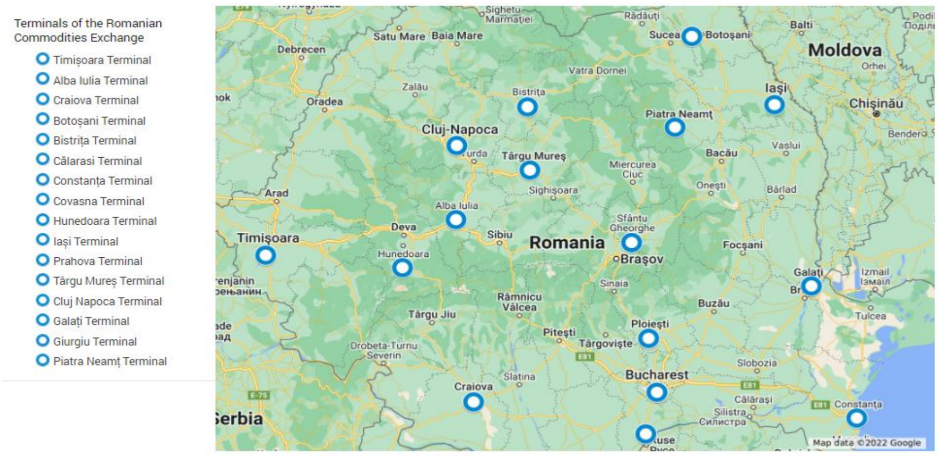

Figure 7. Terminals of the Romanian Commodities Exchange

Source: www.brm.ro/terminale https://www.brm.ro/terminale

Market access is only available to brokerage firms, shareholders and affiliates. The transactions are carried out either by free call in the stock exchange ring or by using the electronic trading platform of the stock exchange.

RCE has organized several specialized rings. There is also a general ring of fungible products in which transactions can take place for any fungible goods, other than those for which there are specialized rings. Quotations are set in each ring.Within each ring are defined the underlying assets (goods) for which trading sessions can be organized. These are specific products. For example, sunflower, wheat, alfalfa, barley, barley, oats, corn, rapeseed and soy are traded in the cereal ring.

Figure 8 RCE rings

Source: Own construction based www.brm.ro

Stock market quotations for wheat are calculated based on data taken at county level from the Information System for the Market of Agricultural and Food Products, provided by the Ministry of Agriculture and Rural Development. from the agricultural field, as well as with the export prices from the port of Constanța. The price (lei / tons) appears as a culmination of those presented above and the volume of sale-purchase requests registered at RCE.

Table 6. Quotations for bakery wheat for January 2021 (Lei / tons)

Wheat delivery	week 31.Dec. 2020-06 Jan 2021	week 07-13 Jan.2021	week 14-20 Jan.2021	week 28.Jan-03.02.2021	Price environment / area
East	928	952	937	980	949.25
West	835	-	925	912	890.66
South	984	902	969	984	959.75
FOB Constanța	1003	1026	-	1134	1054.33
Average price /week	937.50	963.33	943.66	1002.50	
Average price/month	**961,74**				

Source: Own construction based RCE data

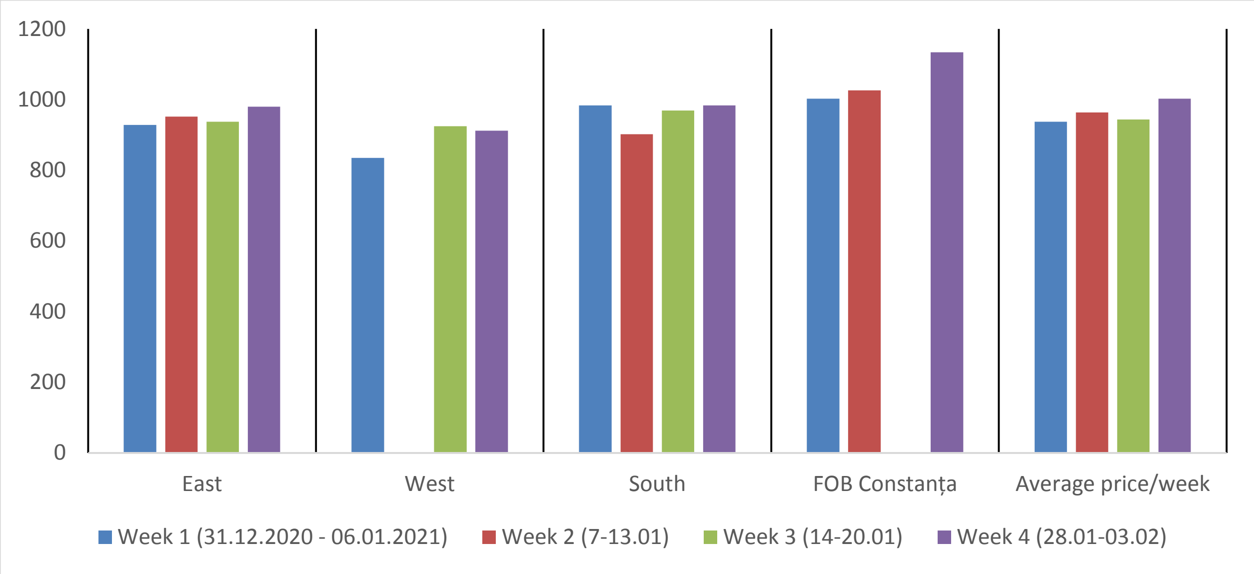

Figure 9. Evolution of wheat quotations within the RCE - January 2021

In 2021, the world wheat market was affected by numerous events:

- the imposition by Russia of export duties on wheat, which has created uncertainty among farmers in that country,
- Prolonged drought in the same country but also in Europe and the USA - greatly reduced the amount harvested.

In conclusion, worldwide, demand remained active, while supply had a general downward trend for the 2020-2021 harvest.

Table 7. Quotations for bakery wheat for March 2021 (Lei / tons)

Wheat delivery	week. 04-10.03.2021	week 11-17.03.2021	week 18-24.03.2021	week 25-31.03.2021	Price environment / area
East	1079	990	1052	988	1027.25
West	986	975	971	956	972.00
South	994	1017	1004	1019	1008.50
FOB Constanța	1145	1133	-	1163	1147.00
Average price /week	1051.00	1028.75	1009.00	1031.50	
Average price/month	**1030,06**				

Source: Own construction based RCE data

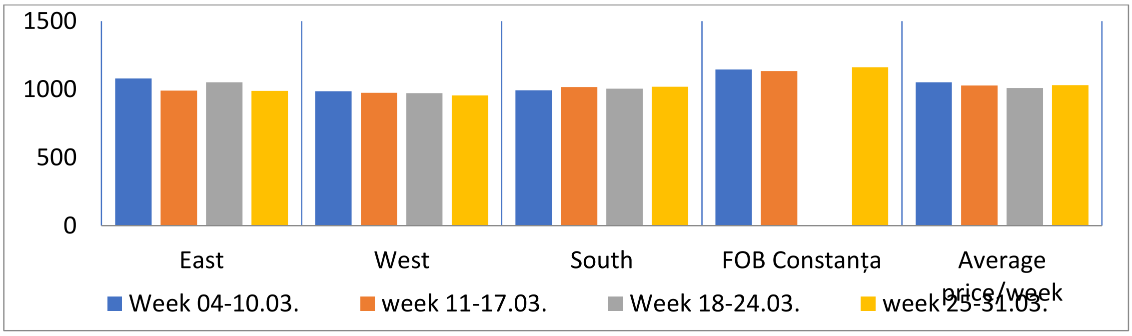

Figure 10. Evolution of wheat quotations within the RCE - March 2021

Table 8. Quotations for bakery wheat for June 2021 (Lei / tons)

Wheat delivery	week. 03-09.06.2021	week 10-16.06.2021	week 17-23.06.2021	Week 24-30.06.2021	Price environment / area
East	936	1016	1000	935	971.75
West	941	941	981	893	939.00
South	970	1008	1003	903	971.00
FOB Constanța	1034	1056	1201	1080	1092.75
Average price /week	970.25	1005.25	1046.25	952.75	
Average price/month	**993.62**				

Source: Own construction based RCE data

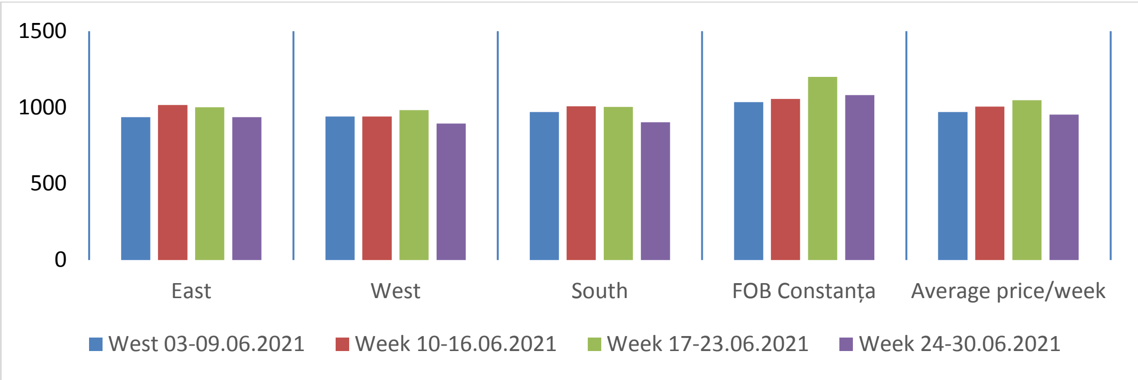

Figure 11. Evolution of wheat quotations within the RCE - June 2021

Table 9. Quotations for bakery wheat for september 2021 (Lei / tons)

Wheat delivery	02-08.09. 2021	09-15.09. 2021	16-22.09. 2021	23-29.09.2021	Price environment / area
East	989	1010	989	978	991,50
West	1046	1016	1045	1014	1030,25
South	960	982	981	1019	985,50
FOB Constanța	-	1008	1066	994	1022,66
Average price /week	998.33	1004,00	1020,25	1001,25	
Average price/month	**1005.95**				

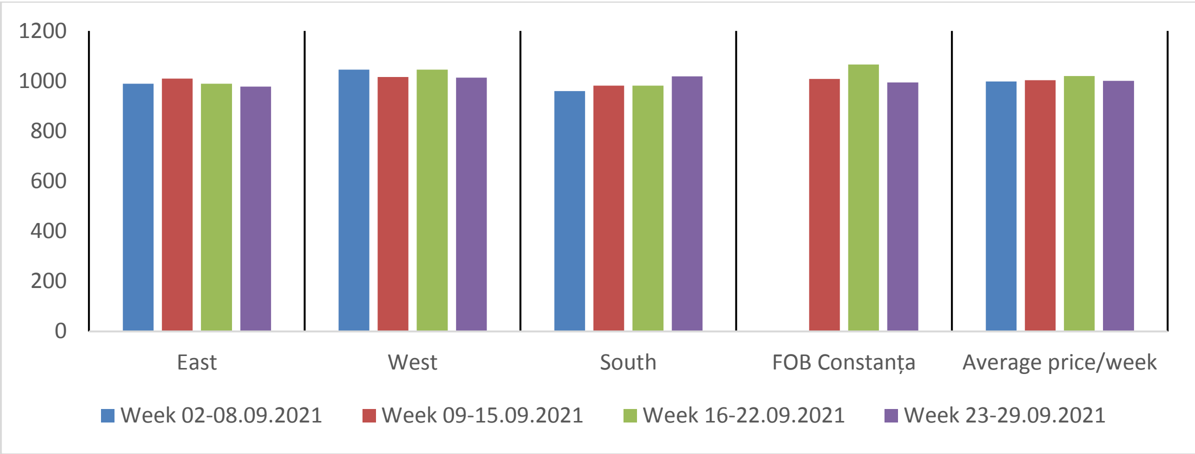

Figure 12. Evolution of wheat quotations within the RCE - September 2021

Tabel 10. Quotations for bakery wheat for december 2021 (Lei / tons)

Wheat delivery	03-08.12. 2021	09-15.12. 2021	16-22.12. 2021	23-29.12. 2021	30.12.2021-04.01.2022	Price environment / area
East	1362	1336	1228	1218	1117	1252,20
West	1135	1236	1301	1000	1263	1483,75
South	1261	1273	1191	1257	1303	1257,00
FOB Constanța	-	1360	1231	1319	-	1303,33
Average price /week	1252,66	1301,25	1237,75	1198,50	1227,66	
Average price/month	**1243,56**					

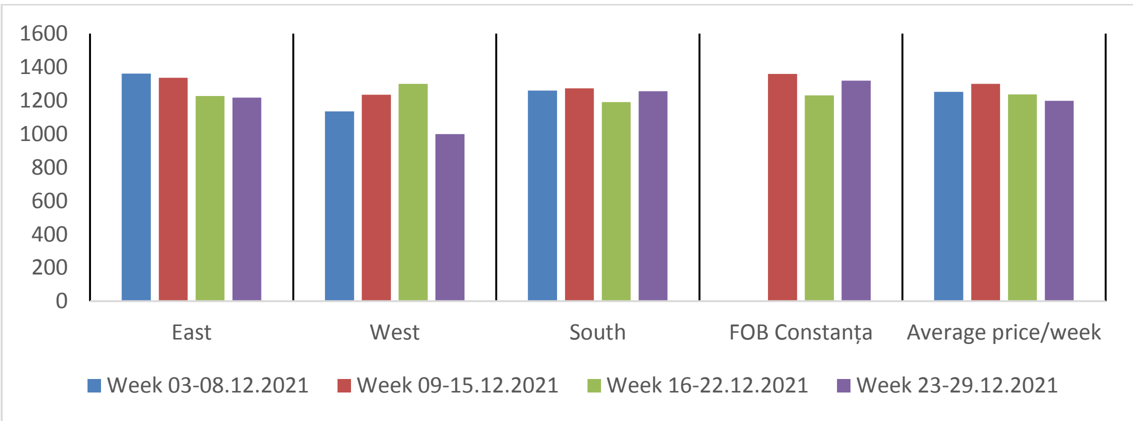

Figure 13.. Evolution of wheat quotations within the RCE - December 2021

The analysis of the monthly average quotations indicates the following evolution of the wheat price at RCE, for the year 2021:

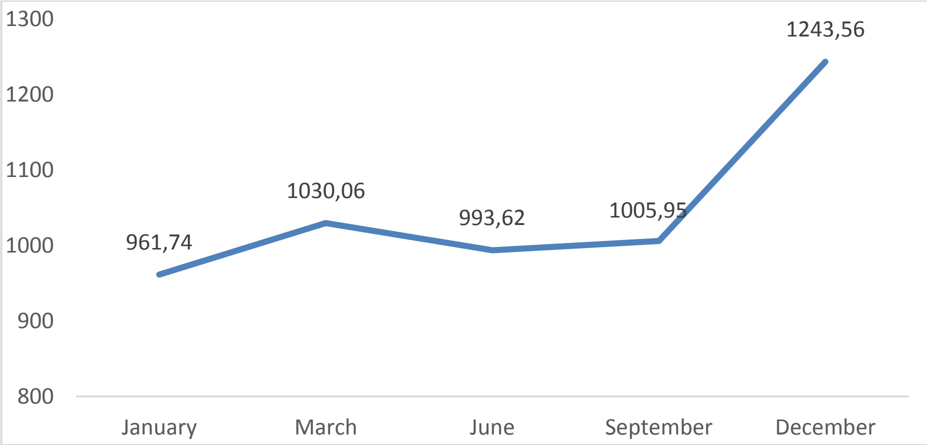

Figure 14. The evolution of the average monthly quotations for wheat within the RCE - January-December 2021

Source: Own construction based RCE data

The perspective of the agricultural year 2021-2022, for the wheat product does not estimate a decrease in prices, due to the maintenance of some equilibrium factors worldwide:

- Romania's "wheat crisis" in Russia will be counterbalanced by Romania, France and the rest of the EU27.
- US "problems" will be balanced by Australia,
- Demand from the Middle East, East Asia and China will remain strong and steady,
- New events in Ukraine / Russia will adversely affect the gray market

DISCUSSION

Romania has a double quality on the cereals market - it belongs to the Black Sea area and at the same time is a member of the EU. The price of cereals at the local level cannot ignore the global and European context, which is influenced by a number of factors, including:

- natural factors (extreme drought in some areas, excessive rains at harvest, etc.),
- The price of wheat in the Black Sea area is mainly due to Russia, the largest exporter of wheat, which has imposed export duties on cereals in order to reduce the price on the domestic market. However, the effect was the opposite, so that the measure further contributed to the escalation of prices on the international market,
- in the financial markets, there is an excessive money supply, which speculatively reaches the grain market as well, which creates a leverage effect. There are also influences related to the euro / usd exchange rate, interest rates, etc.
- the cost of sea transport, which has tripled in the last year.

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BAILE HERCULANE, A PEARL OF THE ROMANIAN BALNEOTOURISM HERITAGE - PAST AND PRESENT

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ABSTRACT

The spa tourism potential forms a special category of tourist resources that since antiquity have generated the oldest form of tourism practiced in Romania - balneotourism. It refers to mineral and thermal waters, therapeutic muds and gases, lakes and therapeutic salt. Romania has a great wealth of natural healing factors, spread over almost the entire surface of the country. One of the oldest and most famous resorts of this kind is Baile Herculane, which is notable for the miraculous healing properties of the thermal waters that have made the resort known since antiquity. From its discovery in antiquity until today, Baile Herculane has become a reference name in the tradition of Romanian spa tourism through hot springs, mild climate with sub-Mediterranean influences, strongly negative ionized air and the picturesque landscape of Cerna Valley, all contributing to development of spa tourism as well as recreational tourism.

Keywords: Herculane, past, present, tourism

INTRODUCTION

According to the World Tourism Organization, the concept of tourist heritage refers to all natural and cultural assets of a territory strictly delimited from administrative-territorial point of view. (WTO, 2022)

The tourist heritage is composed of almost all the components of the natural environment that offer attractive landscapes and tourist objectives.

In Romania, all the variety of relief is concentrated, from the mountainous area to the plain and delta, rich hydrographic networks, various mineral waters, as well as a rich flora and fauna.

Hydrography, represented by surface waters, groundwater, mineral waters, as well as lake and sea waters, supports the elements of life, diversifies the picture of natural landscapes and offers a high attractiveness for tourism through its therapeutic and fishing and recreational value. The highest value is given by the mineral waters in Romania, these being approximately 2500 springs, with a share of 40% of the mineral water reserve of Europe. (Bogan, 2021)

Water, as a tourist resource for various forms of tourism, occupies a priority place in tourism through its many forms of organization: groundwater, springs, hydrographic networks, lakes, Black Sea, etc., through its quality and varied salt content and landscape value.

Due to the multiple functions held in the tourist act, the water generated on the territory of Romania spa, recreational, sports and professional tourism. (G.Erdel, G Erdel, L Istrate, 1996**)**

The spa tourism potential represents a special category of tourist resources, which since antiquity have generated the oldest form of tourism practiced in Romania - balneotourism. In accordance with international balneological standards, it includes mineral and thermal waters, therapeutic muds and gases, lakes and therapeutic salt.

The use of spa treatments dates back over two millennia and were practiced by the ancient people, Mesopotamians, Egyptians, Geckos and Romans, who had a real cult for bathing. The Romans preferred the baths as the most important method of spending their free time, in this sense arranging places for them, similar to the spas and treatment resorts of today. A Roman practice was to build baths around the hot springs they discovered during the heyday of the empire.

MATERIAL AND METHOD

The method used is the case study of Băile Herculane resort, aiming to highlight positive and negative aspects specific to tourism in the area, by collecting and analyzing data obtained to assess natural resources and the attractiveness of tourism in the area, to establish conclusions and proposals to improve tourism.

RESULTS AND DISCUSSION

The past in the Herculaneum Baths

Baile Herculane is one of the oldest spas resort from the world. The name of the resort comes from the god Hercules - son of Zeus and the beautiful Helen, recorded in Roman mythology as the patron saint of hot springs, a symbol of power and balance between physical and spiritual strength. Hercules is said to have passed through the area on his way to the Caucasus in search of the golden wool. He met Corcoaia, a local woman, here. Seeing him weak, she advised him to go into the water of a spring to recover. After a hard day's work her sons bathed in the same spring, but also sick people and animals, injured or bitten by venomous snakes. After a bath in the healing water, they were completely healed. Hercules was asked by another local to help him get rid of a dragon whose villagers had to regularly sacrifice a child so as not to destroy their crops and houses. After defeating him, wounded, the god entered the spring he had learned from old Corcoaia and recovered completely.

The resort is located at an altitude of 168m above sea level, the air here being strongly ionized due to the thermal springs from the area and the surrounding forests.

The legend of the Herculane baths says that the healing effects of the thermal springs on the Cerna Valley were discovered by the Romans with the help of horses, which bathed in the thermal waters, near the Venera spring, healed from wounds suffered in battles and from some diseases. They also found a cure for scabies with the help of thermo-sulfurous waters.

Also, the miraculous and healing effects of the waters of the thermal springs were observed by the Roman soldiers, who recovered their exhausted powers in the wars and regained their vitality. They reported to their superiors about the energies of the water in the Cerna Valley, which treats certain diseases, contributing to the construction of baths dedicated to the hero loved by the Romans, Hercules, thus becoming one of the most sought places for restoring health during Roman rule.

Thus, the foundations of the resort were laid in 102 AD by Emperor Trajan, the Romans introducing the spa cult taken from the Greeks. The Romans built here: temples, baths, monuments and statues dedicated to the gods: Hercules, Aesculapius and Hygieia. The first documentary attestation of the resort dates from 153 AD, a fact recorded in a votive table from baths: ”The gods and deities of the waters, Ulpius Secundinus, Marius Valens, Pomponius Haemus, Carus, Val, Valens, sent as Roman delegates to attend the election as consul of their former colleague Severianus, returning unharmed, raised this gift of gratitude.” During the Roman civilization, the resort was an important attraction for the aristocracy of ancient Rome, who were impressed by the healing power of the thermal waters in the area. (Cristescu I., 2006).

After Roman troops withdrew during the reign of Emperor Aurelian due to pressure from migrant peoples, the baths deteriorated significantly, taking into account the Roman period. In

1736, the governor of Banat during the reign of King Carol managed to rebuild the baths and reconfirm the existence of the baths of Hercules.

The modern and contemporary history of the Herculaneum Baths begins after 1718 in the Habsburg Empire. From 1736 begins the reconstruction and modernization of the baths, the access roads to the resort, as well as the construction of most of the buildings from resort. During the Austrian domination the resort is visited by many personalities: Emperor Joseph II, Emperor Francis I and Empress Carolina, Emperor Franz Joseph and Empress Elizabeth who wrote a diary about the Herculaneum Baths where they were presented as distinct and charming, King Carol I of Romania, King Alexander of Serbia, King Mihai, Queen Mary, etc. In 1847, the famous bronze statue of Hercules (the symbol of the Baile Herculane resort) was erected, the work of masters Romel Mayer and Glanz of Vienna. In 1852, the Emperor of Austria considered the Herculaneum Baths to be the most beautiful resort on the continent, and Empress Elizabeth (Sisi) mentioned in her diary about the Herculaneum Baths and the distinct and enchanting moments spent here. It could be said that this was the glory period of Baile Herculane resort, during this period several representative buildings were built for Baile Herculane resort: Decebal and Traian hotels, Casino building, Austrian Imperial Baths. (Gh. Popovici, 2009)

The Herculaneum Baths in Banat and Karlovy Vary in Bohemia are two of the most developed spa towns during the Austro-Hungarian Empire and at that time were rivals for the crowned heads who visited them as well as for Europe's aristocrats. Their architecture was similar, even the natural setting - ideal refuges for crowned heads and for Europe's aristocrats. But today, the Czech resort shines like a Bohemian crystal, while Herculaneum remains only a faint memory of a flourishing era.

The place of origin of the Baile Herculane resort is represented by the Roman Baths, in a superb setting between the rocky slope and the Cerna River, here operating since 1975 the Roman Hotel.

Baile Herculane Casino - the building was built at the end of the 19th century, being a true historical monument. The building is built in Baroque style. Right next to the casino stairs grows a Sequoia Giganteea - a tree declared a natural monument. The building is in the process of being rehabilitated, but the works are not yet completed (maybe 10%).

The Austrian Imperial Baths - were built between 1883-1886, according architect Ignac Alpar plans. They were among the most modern spa buildings of the time. The building is built in Baroque style.

The Bath of Hercules is the oldest bath from the resort, originally built and used by the Romans. On the occasion of the restoration of the Herculaneum resort in the first part of the 18th century, Roman vestiges were discovered here: a hollowed-out stone bathtub for partial baths at the elbow and knee, excavations in the rock for general baths, coins.

The stone bridge with a covered corridor is located at the end of Hercules Square, being one of the remarkable technical achievements of the resort in the 19th century, being built in a curve in 1864.

Statue of Hercules - is made of cannon iron by German craftsmen Glantz and Romelmayer. It was donated to the resort by Austrian Archduke Carol as a tribute to the officers and soldiers of the Imperial Army who did well in the treatment of the resort. The statue was erected in 1847 and became the symbol of Baile Herculane resort.

Villa Elisabeta (originally called Villa Tatartzy) - was built in 1875 by the administrator of the resort Carol Tatartzy. In 1887, Empress Elisabeth came to live here, from which time the villa was renamed Villa Elisabeta. It is said that Empress Elizabeth (Sisi) felt very well in these places, as evidenced by the notes in her diary. The Empress even wrote a poem of 82 verses dedicated to the beauties of this place.

Pavilion 3 (Hotel Francisc, Hotel Severin, Hotel Apollo) - is located in the Imperial Historic Center. It was built in 1824 and housed Emperor Francis I and his wife, Empress Carolina. At the south-west end of the pavilion is an octagonal terrace with a baroque-roofed roof.

Pavilion 6 (Hotel Archduchy Iosef, Hotel Dacia) - originally on the site of this pavilion was built in 1824, but it was burned down in 1900. In 1906, on the site of the old feast was built the current building of Pavilion 6. This pavilion was the last and at the same times the most imposing building from Imperial Center. The building has a structure with basement, ground floor, mezzanine and three floors and was equipped at that time with a hydraulic elevator.

Hebe Bath - was built in 1826 and rebuilt in 1864. It is located in the Imperial Historic Center, between the Stone Bridge and the Apollo Hotel. It had eight cabins and a pool, all made of white and red marble.

Apollo Bath - is one of the first baths built in the resort in Roman period of the development of the resort. Over time, it was rebuilt by several times and had several names: Baia Comuna, Baia cea Mare, Baia de sindrila, Baia Ludovic, Baia Crisan. It was equipped with three cooling pools, 32 cabins and three red and white marble pools for the bathroom, one for men, women and the military.

The present in the Herculaneum Baths

We can say that the main attraction of the Herculaneum Baths is the miracle of the thermal waters. In addition, the climate with sub-Mediterranean influences, the strongly negative ionized air, with effects in physical and mental recovery, as well as the particularly picturesque landscape of the Cerna Valley are highlighted. The main therapeutic factor is the richness of sulfurous, thermo-mineral and chloride-sodium sources.

The spring water has free flow and is used in the resort in arranged pools, and the drilling water is captured and transported to the treatment bases of the existing hotel complexes in the city. Due to the healing effects of the waters and the age of about 2000 years of their exploitation, Baile Herculane resort is listed as one of the most famous from Europe. The natural healing factors from Băile Herculane: sulfurous, chlorinated, sodium, calcium, magnesium, oligomineral, hypotonic, mild climates, sub-Mediterranean thermal mineral waters have beneficial effects on the human body. Also, the mineral waters from Baile Herculane have multiple uses: the cosmetics industry (creams, face water, etc.). There are significant reserves of groundwater, of which the thermal mineral springs stand out (Seven Hot Springs has the most radioactive waters in the country), due to the curative effects and the age of exploitation, the resort of Băile Herculane being famous in Europe. It is worth mentioning the mineral and flat waters from Calina and Băile Herculane, which are still used today: Perena and Herculane water.

As for the hot springs, it is assumed that they came from a volcanic activity. Volcanic activity is visible at the Grotto with steam, a cave hollowed out in the rock, from where steam comes out of the ground, against the background of noises coming from the depths. (Pricăjan A., Airinei Ș., 1981)

The thermo-sulfur springs and the thermo-saline springs of Hercules have healing waters for a series of disease and have been baptized among the people: foot bath, eye bath, cold bath, women's bath. The main therapeutic element of the thermo-sulfurous water from Baile Herculane is the thermal sulfur, which is soluble sulfur dissolved in deep thermal waters. (Ș. Negrea, A. Negrea, 2002).

The thermal mineral waters from Herculane stretch on the Cerna Valley, on a length of 4 km. With seven Hot Springs downstream, and downstream, the Eye Spring.

In Herculane there are 20 hot springs, of which 10 main hot springs are used today, with a relatively constant flow, high degree of mineralization (3-6 g/l) and a temperature of up to 62ºC, but most waters vary as temperatures between 35-45ºC. The waters of the Seven Hot Springs are the most radioactive waters from Romania, their degree of mineralization increases from north to south, and the chemical composition varies from source to source. A characteristic of mineral waters is that they contain hydrogen sulfide in high concentration (up to 60 mg/l).(Popovici, 2016)

The types of mineral waters found in Herculane are:

- thermal chloride-sodium mineral waters, bicarbonate, slightly sulfurous with a mineralization between 0.5 - 2.6 g/l and a temperature between 38.5 - 53.5ºC;
- chloride-sodium, bicarbonate, calcium thermal mineral waters with a mineralization between 0.6 - 3.5 g/l and a temperature between 46 - 56ºC;
- chloride-sodium thermal waters, brominated, iodized and sulfurous with a temperature reaching 62ºC and a mineralization between 3.87 - 7.93 g/l;

The Herculane thermal mineral springs, with the waters used in spa treatments, were divided into five groups:

- Group I - Seven Sources;
- Group II - Hercules;
- Group III - Diana;
- Group IV - Neptune;

Venera Bath, after the name of the goddess of spring, love and beauty, is famous for treating diseases in women, this being among the first sources discovered by the Romans, also known as Old Bath, French Bath, Women's Bath, Pumice bath. (Bălteanu, 2007)

There are many legends about the healing miracle of the thermal waters of Herculane including the one of a patient completely ankylosed due to rheumatism, which could no longer stand on his feet, not even on crutches. Following the treatment, his health improved, he managed to get to his feet, and after two months of treatment, he was able to walk on his own.

The continued existence of the baths is due to the miraculous effectiveness of the hot springs which have always been considered a gift from the gods.

Also, the locals used to use the water as a treatment for various diseases, sitting in the hot water for 2 hours, after which they wrapped themselves and slept in the open air until the next day, when they took another bath, ate and went to their homes. This belief in the beneficent springs of the Cerna Valley is still preserved today, practicing this method of treatment in nature, and people can be seen camping on the side of the road, for hot baths, either summer or winter, year after year.

In addition to the beneficial and healing effect of the thermal waters of Herculane, the strongly ionized air with negative ions, comparable to that of the Swiss resort of Davos or Niagara Falls, the built heritage of great architectural value, the mountain landscape is invaluable and represents an important link of tourism from the area.

The particularly picturesque natural setting of the resort, with secular forests of firs, pines, oaks with a climate with calming action, with sub-Mediterranean influences, are the premises for the development of hiking tourism. In this sense, hiking trails have been created around the resort, arranging gazebos and benches for rest, the beauty of the landscape as well as the fresh and clean air, rich in negative ions, offering conditions for relaxation and recovery of physical and intellectual strength. Empress Sisi, who was a five-time guest of the resort in 1884, 1887, 1890, 1892, 1896, and her husband, Emperor Franz Joseph, enjoyed walking the trails around the resort, accompanied only by a bridesmaid and a local guide.

During the communist period, the Baile Herculane resort experienced an unprecedented development, in the 70's and 80's the big hotels were built, reaching a capacity of over 5000 accommodation places. Then the Roman Hotel was opened, the emblem of the resort of those times, the Hercules Hotel, Minerva, Diana, Aphrodite, Dacia. The decline of the oldest spa in Romania began as in many other cases after 1989.

Although steps have been taken in the reopening and modernization, after 1989, of some famous hotels: Roman, International, Diana, Aphrodite, it is necessary for Herculaneum to go through a broader process of modernization and rehabilitation of the existing material base, such as and increasing the quality of services provided.

Swinging between the two essential features, spa and cultural, Herculane used his resources to resist. Its status as a spa locality, due to the permanent connection with natural resources, was the only solution for the survival of the resort over time.

From the point of view of the cultural identity of the city, marked by traditions and architecture, extremely important in the development of the Herculaneum Baths, the “Hercule” brand is currently in decline. The historic center is almost dead, and its reactivation is stopped not only by legal issues, but also by the high level of quality targeted, by the permanent reference to the past of the resort. The historic center has practically become a tragic setting for a glorious sunset, under the sign of decay. Herculane offers a journey through time and space through the various messages conveyed by the relationships between the main components of the historic center and beyond.

CONCLUSIONS

About Herculane we can say that he lost the battle with the other famous profile resort in the former Austro-Hungarian Empire, Karlovy Vary. The Czechs won, with an emphasis on investment and promotion.

Due to its physico-chemical qualities and high therapeutic value, the thermal and mineral waters of Herculane are similar or even superior to the mineral waters of Baden-Baden - Germany, Bolzano-Italy or Karlovy-Vary - Czech Republic, but poor infrastructure development and poor investment made in the area, places the resort to a lower position.

In order to relaunch it, Baile Herculane Resort should be included in a promotion strategy at national and international level. Among the marketing solutions would be the promotion of the resort as the oldest spa destination from Europe, as well as the membership of the Baths in the former Austro-Hungarian Empire, which would make the resort more attractive to tourists coming from countries that made up the former empire.

In order to relaunch the Herculaneum resort on the international tourist market, the emphasis must be on diversifying the tourist offer, as well as on improving the quality of the services offered, which can be achieved by accessing European funds and more. Also, given the current trends in the tourism market, it is imperative to promote the concept of active vacation as well as some themed tourism products.

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MONEASA, A SPA OF THE AUSTRO-HUNGARIAN MONARCHY: THE SLEEPING BEAUTY

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ABSTRACT

The study presents the spa resort of Moneasa at the time of its foundation and today. Special attention was paid to the presentation of the waters of the settlement and the tourist attractions of the place that are interesting and exploitable. The study summarizes data from literature sources and personal visit experiences. Moneasa's attractions and preserved spa culture, in addition to the many achievements achieved, require not only financial resources but also a more thoughtful marketing management.

Keywords: rural tourism, spa, destination marketing, thermal water, Codru-Moma Mountain

INTRODUCTION

The breaking springs of Moneasa were known as early as Roman times, as evidenced by contemporary records. It was also a place visited in Turkish times. The settlement was mentioned as Monyásza (1597) and was famous for its thermal water.

The detailed tourist exploration and description of the region and the Codru Moma Mountains was due to Gyula Czárán, a pioneer in tourism, who was the first to write about the area in scientific detail. Its memorial plaque is located next to the main street (*Figure 1-2*), and his grave is in the local cemetery.

The aim of the study is to present the natural values and built heritage of Moneasa, drawing attention to the tourist potential of the place.

Figure 1-2: Rock in memory of Gyula Czárán.

MATERIALS AND METHODS

The paper is based on literature data. The material was supplemented by information received from Romanian colleagues and the experiences of the author and his personal visit in Moneasa town. The old postcards used to illustrate the material come from the internet; the contemporary images are photographs by the author.

RESULTS

A brief history of the spa and the town

Moneasa is located on the northeastern edge of Arad County, in the vicinity of Bihor County, in a narrow valley surrounded by mountains. The history of the spa dates back barely 150 years, although the healing effects of its thermal waters were already known in Roman times. Extensive use of thermal water resources began in 1866. The name of the "spa" was officially donated from Vienna by the Ministry of the Interior of the Austro-Hungarian Monarchy on 16 May 1886 (Linc – Marusca, 2008). Local thermal water is karst water, which contains bicarbonate, magnesium, calcium, sodium, and it has a beneficial effect in several diseases such as nervous and motion system problems, gynecological and gastrointestinal disorders (Rusu – Isac, 2009). The beneficial effects of thermal water are well complemented by fresh air and the surrounding forest suitable for long walks.

The construction of the bathhouse, the most important building of the settlement at that time, was started in 1881 (unfortunately, only a fraction of it is still in ruins today) (*Figure 3-4*). The construction (and other developments of the settlement) is associated with the name of Count Frigyes Wenckheim, who had extensive estates in Arad and Békés (Hungary) counties.

Figure 3-4: The bathhouse: past and present

Iron ore mining also took place in the area in the 18th century, and there was also a Moneasan smelter, the ruins of which can also be seen. Limestone, red and black marble were mined in the surrounding mountains until the early 20th century. The limestone was transported to the Mezőhegyes sugar factory, while the marble was used to decorate the buildings of Arad and the castles of Count Wenckheim. (In the recently renovated Wenckheim Castle in Szabadkígyós, the guide mentions that the marble fireplaces are from Moneasa.)

In 1893, a narrow-gauge railway was built by the Count between Sebis and Moneasa to transport stone and bath guests (*Figure 5*). At the same time, the Arad elite built a series of villas in the settlement, many of which still operate as boarding houses.

Figure 5: The narrow gauge steam locomotive

Frigyes Wenckheim and his wife, Krisztina, also reminds the statement of the stone cross of the Roman Catholic Church they build (*Figure 6*).

Figure 6: Moneasa, Roman Catholic Church

The importance of waters at Moneasa

In addition to natural springs, 5 wells have been drilled (between 1972 and 1975) to provide mezo-thermal water (25-32°C) to this day (Marusca 2008). The wells of the wells are partially nourished by the water plant network and partly serving drinking and bathing cures. In the Communist period, 1000 people took the balneology services approximately every year.
Moneasa was beneficiary of major investments for the construction of 3 hotels with hundreds of beds at that time (Dragan, 2013).

After the revolution, the place was in a vicious spiral: the tourist attraction decreased, thereby reducing revenue. Decreasing financial resources led to the deterioration of the standard, which resulted in fewer guests.

The EU's Rural Development Programs (*Figure 7*) have given the opportunity to develop a number of improvements. By 2011, the number of guests reached 95068 people, which unfortunately doe to not fully clarified reasons for 2014 decreased to 11 people (Imecs et al., 2015).

On 17 September 2017, a particularly strong windstorm caused massive damages to the town’s houses (nearly half of them were damaged), park trees, forests and vehicles. Recovery requires significant resources (Mihaila et al., 2019).

Figure 7: Sign of a Crossborder Project

The old bath house was originally 80m long-building divided into cabins, where it could be bathed in red marble casing tubs. The restoration of these seems to be hardly possible.
The bathhouse was named Vila Nufar after the water lilies of the nearby lake were brought from Baile Felix (*Figure 10*). The lake still exists, it is fed by flowing spring water, but its environment is neglected.

There is also a strand and a swimming pool in the center of the village (*Figure 8-9*), which is very popular during the summer season. There are bungalows, cafeteria and a restaurant on site as well.

There are a number of streams around the town (*Figure 11*) whose water is clear and in which the brown trout live and breed. The longest stream/river bears the name of the settlement and meanders along the "long valley". Ruset et al. (2008) surveyed 50% said Moneasa's strength in the landscape, 30% said it was thermal water, and 20% voted for the river and streams.

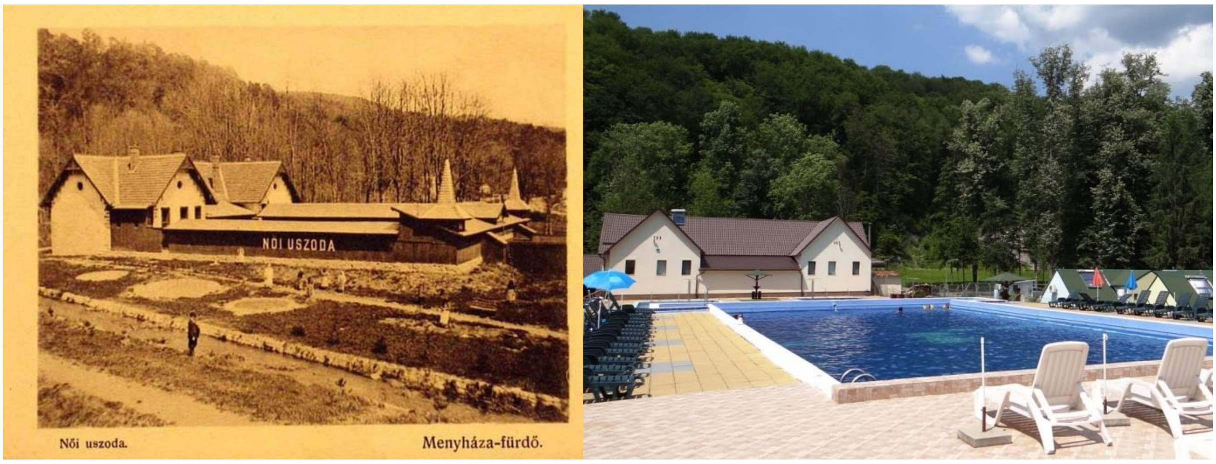

Figure 8-9: The local swimming pool

Figure 10-11: The pond of water lilies (left) and a stream with a retro picnic area (right)

Lake Linistit (*Figure 12*) is a very well-known attraction point of the town, which is a small artificial lake with boats, hydro-bikes and the possibility of fishing. The lakefront guest house has a restaurant and bar.

Attractions and events

The marble quarry has not been in operation for a long time and is open to the public. Black on the lower levels and red on the marble provide an excellent background for photography. At the other end of the settlement, near the town hall, is a monument to the stone carvers.

Figure 12: Lake Linistit

There are many well-marked hiking trails in the surrounding mountains.

Of the karst formations, 27 caves are worth mentioning (not all of them can be visited), as well as 6 major sinkholes.

There are two major events in the town mentioned by Adamov et al. (2021):

- „Festival of song and game from Tara Zarandului",
- The parade of the folk costume and the Crafts Fair.

Accommodations and gastronomy

Accommodation is linear in the valley of the Codru Moma Mountains, while Moneasa is a hub thanks to the spa (Tatar et al. 2008). There are plenty of accommodation options in the town (hundreds of beds, but it is difficult to give an exact number because COVID is temporarily closed due to the epidemic and renovations). Bocu and colleagues estimate 995 beds (2013).There are plenty of accommodation options in the town (hundreds of beds, but it is difficult to give an exact number because COVID is temporarily closed due to the epidemic and renovation. Hotels are usually 3 stars (e.g. Hotel Park, Hotel Blue Stag) (*Figure 13-14*). They are waiting for their guests renovated, but we can also find old and new guest houses and tourist accommodation here.

Hotel Park, Hotel Santana etc. also provide wellness and medical services to their guests. Among the guests, the older age group is accordingly overrepresented. This feeling is reinforced by the presence of the elderly in the park and on footpaths.

The Cabana radiates a distinctive retro feel to "DALLAS" (in the good sense of the word) (*Figure 15-16*) and makes traditional Romanian dishes excellent. Freshly caught grilled trout with garlic and polenta are unmatched, but they also offer tripe soup (*ciorba de burta*), grilled sausage (*mititei*), cottage cheese donuts (*papanasi*) and more.

Those who like the flavors of international cuisine will find it on the menu of restaurants and in the local pizzeria.

Figure 13-14: The Hotel Blue Stag (Vila Cerbul Albastru) now and before

Figure 15-16: The Cabana “DALLAS”

In the farmers’ market (*Figure 15-16*), guests can buy good quality local products such as milk and dairy products, vegetables, fruits, jams, syrups and handicrafts so cheaply.

Figure 15-16: The farmers’ market

CONCLUSIONS

In general the competition among destinations is huge. The number of locations is growing year by year, both domestically and internationally. No longer is a special attraction required for success. It may be enough to be known have an effective management and marketing.

The buildings, accommodation and road network of the settlement have undergone a number of renovations, partly with EU funds and partly with private investors. Nevertheless, further improvements are needed.

The conditions of the natural environment provide excellent opportunities for rest and active recreation.

I agree with Bocu and colleagues (2012) that at present, medicine and treatment based on local thermal waters is in the public consciousness, and perhaps the emphasis should be on wellness and health, which would be a buzzword for the younger generation as well.

The marketing of the destination in the area has already started and is underway (attractions are available on Romanian tourist websites). However, it would be necessary to draw attention to the opportunities provided by Moneasa and its surroundings at least in the south-eastern counties of Hungary (Békés, Csongrád-Csanád). The marketing work carried out here would arouse interest in the mountain resort closest to Békés County, and more people would know about the sister settlement of Békésszentandrás. Perhaps in addition to the current declining number of guests, more Hungarian tourists could also contribute to waking this Sleeping Beauty.

Acknowledgments

I would like to thank to Professor Dr. Ramona Lile Rector (Aurel Vlaicu University, Arad) and Professor Dr. Csősz János (USAMVB, Timisoara) for drawing my attention to this spa resort, to the town of Moneasa and its touristic values as one of the closest mountain resorts to our region and encouraging me to visit the place.

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PARALLEL STUDY ON THE LEVEL OF AGRICULTURAL DEVELOPMENT IN THE WESTERN DEVELOPMENT REGION FROM ROMANIA AND THE NORTH WEST ZONE OF NIGERIA

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ABSTRACT

This study aims to examine the parallel level of agricultural development in the West Development Region of Romania and the North-Western Region of Nigeria. The production of crops and livestock shadows an increasing trend in the region and are majorly locally produced products such as maize, rice, millet, soybean, wheat, sorghum, barley, potatoes, grapes, pork, poultry, meat, milk, eggs. As a result, made Romania the second higher producer in the European Union Regions of agricultural harvests. North Western Zone with about 26% of Nigeria's total area has enormous agricultural resources and diverse agro-ecologies that support productivity growth of the home cultivated crop, livestock, fishery, and forestry sub-sectors, but these have not been fully exploited. The trends and opportunities for sustainable level development of agriculture based on available resources cannot be overemphasized. More than 70% of the population in the Northwest of Nigeria are engaged in agricultural production or other occupation directly or indirectly dependent on agriculture. The farm holdings in a realistic global size appear to be very smaller in the study area, the share is held at an average of about 3.66ha/household. Similar to the reported small-sized farms in the Northwestern Nigeria of average farm size of 1.8 ha/farming household is notably due to an outdated land tenure system that constrains access to land. Despite the significant roles of agriculture in employment generation, Gross Domestic Products (GDP) growth, and foreign exchange earnings, the potentials of this sector are far from being realized in Northwestern Nigeria compared to the West Region of Romania. This has unpleasant implications for food insecurity, widespread poverty, and sustainable economic development.

Keywords: Agriculture, WestRegion, NorthWest Zone, Production

INTRODUCTION

The level of agriculture in the context of the green economy cannot be overemphasized and critically examined in the two regions of different continents. The West Development Region (WDR) is positioned around the western cardinal axis of Romanian four administrative Regions and also among the divided Europe region located in the Danube, Kris, Mures, and Tisa known as DKMT, with a common boundary to Serbia and Hungary Countries. It comprises 4 counties; Arad, Caras-Severin, Hunedoara, and Timis administrative territories (including forty-two cities, twelve metropolitans, two hundred & eighty-one communities, and 1,327 villages (Osabohien et al. 2019) as shown in Figure 1a. The Region has five major categorized cultural tribes based on its inhabitant’s settlements across the counties. Also, the North West Zone of Nigeria (NWZ) is one of the six geopolitical zones which comprises seven of the country’s 36 states: Kaduna, Kano, Katsina, Jigawa, Sokoto, Kebbi, and the Zamfara States as shown in Figure 1b below.

Figure 1a. Map of Romania showing the West Development Region

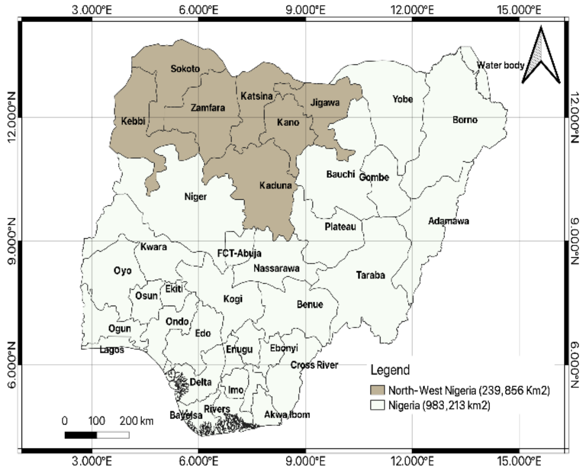

Figure 1b. Map of Nigeria showing the North-West Geopolitical Zone

The WDR account for a geographical land is of 32,034km^2 having a 13.4% share of the whole national land of about 238,000 sqm total land area, and noticeable agrarian country in EU (Fehér et al., 2016) and North West Zone of Nigeria (NWZ) has 26% total land area of the country's 983,213km^2 surface. They are characterized geographically as an agrarian inhabitant; small size farmers dominate production with an average of 3.66 ha and 1.8 ha per holding outdated land tenure system. NWZ has an average holding of 7.4 persons as its second in the country, while WDRN has 2.627% persons per holding, the highest-rated at 45.8% in the whole of Europe. Both have enormous agricultural resources and diverse agro-ecologies that support productivity growth of the home cultivated crop, livestock, fishery, and forestry sub-sectors, the crop production, and animal production follow an up-growing trend, but these have not been fully exploited within the contextual level of agricultural development, from the perspectives of different stakeholders along agricultural priority value chains in the areas.

This study will contribute to the economic policies by triggering the process of large-scale production and commercialization of agricultural commodities with a competitive advantage which will directly offer strategic policy decisions in the agricultural sector that can lead to broader economic, social, and environmental gains in the study area at the long run.

MATERIALS AND METHODS

Materials used are works of literature studies, articles, and statistical data reports from National Bureau of Statistics, Nigeria (NBS), National Institute of Statistics from Romania (NIS): TEMPO online database, Statistics Research Department (SRD), FAOSTAT, World Bank 2020 Report, Agricultural Ministries Database information system among other secondary documents. The study employs fundamental economics research approaches and theory development from the collection and selection of working materials to the processing down to concluding.

RESULTS

Agricultural production's objective is to provide food needs and growth of the national economy given a priority role to socioeconomics, safety climatic changes, and livelihood sustainability functions of human wellbeing. Several decades ago, WDR has witnessed negative population growth from 1,771,480.00 people in 2020 to 1,758,582.00 inhabitants out of 19,201,662.00 country population (NIS, 2022), the NWZ had a population of 48,942,307 or 25% of the country's population in 2016, and increased to more than 90 million residents and stood the most populated zone (45%) in the whole Country's larger population of about 210,100,000 million people (NBS, 2021). This implies that the constant several factors are associated with the decline, ranging from the aging, migration, high mortality, covid-19 pandemic, and lower natural birth rate while rapidly increasing of inhabitants in NWZ and all these trends have direct or indirect unpleasant implications for food insecurity, widespread poverty, and sustainable economic development.

Table 1. Residence population of WDR of Romania and NWZ of Nigeria at 2022

Microregions, Development Regions, and Counties of Romania	2006	Years 2020	2021
	MU: Persons		
ROMANIA	22,280,000.00	19,328,838.00	19,201,662.00
WEST REGION	:	1,771,480.00	1,758,582.00
Arad	:	415,910.00	413,030.00
Caras-Severin	:	269,551.00	266,283.00
Hunedoara	:	380,105.00	373,769.00
Timis	:	705,914.00	705,500.00
NIGERIA	140,538,305	206,139,587.00	210,100,000.00
NORTH WEST ZONE	35,673,665.00	**87,230,785.00**	90,789,000.00

Source: (NIS, 2022): POP105A_3_3_2022; (NBS, 2021)

The number of farms in the EU has been in sharp decline, but the amount of land used for production has remained steady (Feher, 2017). The world's total land area stood at about a 13,395Billions ha; arable land is estimated at 11%, meadows at 22%, and forest area at about 30%. Global average arable land per inhabitant is 0.35ha, WDR has 0.495ha, and the NWZ account for 0.219ha which characterized the regions as small-scale farmers according (NBS, 2020). The West Region has an important economic treasure, having a cultivable agricultural area of about more than a 1.8million ha with a national average of 4.9%, of which arable cropland is 58.5%, pastoral land of 11.3%, grassland 13.6%, nursery, and orchards 1.5% among others (NIS, 2022). The status of legal holding of agricultural land can much be found in the western region than that recorded nationally, millions of crop cultivated areas are found into scattered smaller plots and prevent the progressive expansion of food production to meet human needs (Feher et al., 2016; NIS, 2022). North West Zone has accounted for about 13,271,431 million ha of crop cultivated area with maize, sorghum, millet, rice, soybean, legumes, vegetables, and livestock farming including pork and poultry animals. The production is done under sparse rainfall ranging from 600 to 1,500 mm and it was observed that these crops are normal national food diets of the inhabitants.

Table 2. Agricultural Land Area explorations and Holdings in WDR and NWZ, 2020

AREA	Average family Size	Land Area in Total (ha)	Arable Land Area (ha)	Share of agric. in GDP (%)
North West	7.4	23,985,600	13,271,431	
Nigeria	5.5	98,321,300	43,739,462	22.0
West Region	2.627	3,203,400	1,864,096	
Romania	2.627	23,800,000	13,826,000	4.4

Source: (NBS, 2020; FAO, 2020)

The land pressure access for extensive agricultural production depends much more on the factors such as population growth rate, food needs of the populace under given trends of seasonal and annual changes in crops and cropped area, the geographic variability in farm size and cropping intensity, causing around 460 million people worldwide believed to suffer from malnutrition (Feier-David et al., 2020). Nigerian national average household size is 5.5persons, while urban and rural household sizes are 4.8 and 5.9persons respectively. North West Zone has an average holding of 7.4persons and is second after North East Zone with the highest household size of 7.9persons (NBS, 2020). The 2021 population density in Romania is 84persons/Km^2, that is 218persons/m^2. This implies an average of 2.63persons per holding and where the highest rate is recorded at 45.8% in the whole of Europe. The household size increases labor availability which can be used for diverse agricultural activities.

The total National production in 2020 was 28,672,504 which is a remarkable increase as against 18,615,000 in the previous year, North has 54% and South 46% of the production which is still not enough to feed the nation's continuously growing adult population of more than 70% who are engaged in subsistence agriculture production and animal production of about 30% (FAOSTAT, 2022). Both regions have greater productive land over the global productivity in either continent. Romanian economy has witnessed solid growth over the recent years, ranking among the fastest-growing in Europe results in its products being exported worldwide, registering the biggest producer of wheat crop of over 10MT, with 4,836kg/ha means average. The same goes with other important crops like Sunflower (3.150MT), barley, peas, and rapeseeds which keep its number one position production (Rujescu et al., 2017; NIS, 2022). While Nigeria is a global leader in the agricultural production of palm oil crops over 1MMT, cassava at 59MT, making it the world's largest producer balancing to approximately 20% of global production. Both two countries have a significant influence on the world's total gainful employment with an index share of 21.2% for Romania and 35% for Nigeria in 2020.

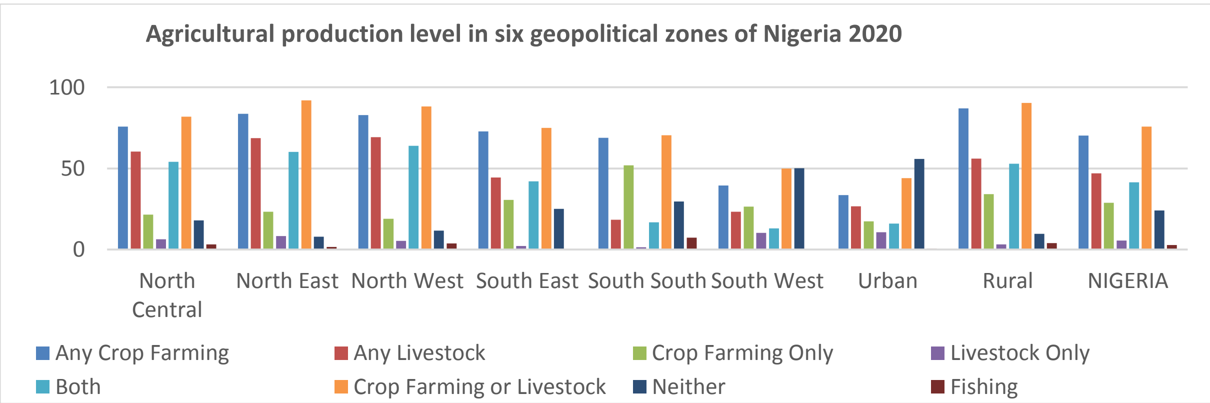

Figure 2. Showing the Agricultural production level in six geopolitical zones of Nigeria 2020

Source: FAOSTAT, 2022

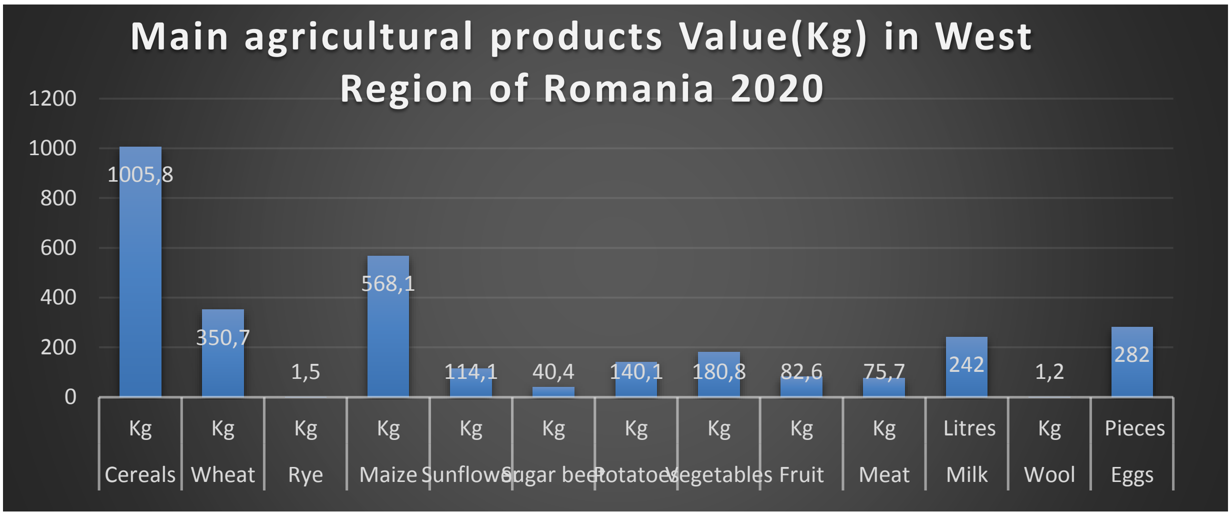

Figure 3. Showing the Value of Agricultural products in West Region of Romania 2020

In the world production arena, the Share of agricultural GDP growth in Romania is 4.4% and the Nigerian share is higher at 22%, while for global crop per capita is more at 0.48% than 0.20% and likewise growth per capita formulation is around 21.3% and 10.92% respectively. The significance and positive contributions of the countries can be seen from the potential of the region's agricultural diversification activities.

The livestock production in both the study is at the subsistence level for self-consumption. The finding of this study reveals a level of stability in the poultry and Pig production arena, NWR in 2020 accounts for about 4, 087,654millions poultry, a decline against 4,599,885million in 2019, out of a national count of about 71,183,431million and 75,364,575million poultry respectively. Also, the pigs of about 949,632million against 944,700thousand in 2019 showed a sliding increase (NIS, 2022). Generally, the regional trends in the production of animals show a decline in the past decades for all the species, but in recent times the studies have shown slower recoveries along with crop production faces with cutting edge in the processing of meat, milk, and egg (Băneș et al., 2020).

DISCUSSION

There is a constantly declined population in western development region and could be due to migration and aging population, the mortality rate is relatively high coupled with pandemics, natural population growth is negative, while in North West Zone it records the rapidly increasing of inhabitants, all these trends have direct or indirect unpleasant implications for food insecurity, widespread poverty, and sustainable economic development.

Agriculture is still at subsistence and semi-subsistence level, practiced in small farms of an average of 3.66 ha and 1.8 ha per holdings respectively. Notably due to population density and outdated land tenure system that constrains access to land, consequently deteriorates commercialization agriculture along the value chain of major crops in the study area.

Both have enormous agricultural resources and diverse agro-ecologies that support productivity growth of the home cultivated crop, livestock, fishery, and forestry sub-sectors, The production of crops and livestock follow an increasing trend in the regions, but these have not been fully exploited within the contextual level of agricultural development, from the perspectives of different stakeholders along agricultural priority value chains in the areas.

More than 70% of either population are engaged in agricultural production or other occupation directly or indirectly that dependent on agriculture, which invests in higher value-added products and cover more than one of the sectors in the agri-food system.

In conclusion, the potentials of this sector are far being realized from the downstream to the upstream areas of the agricultural value chains compared to the developing and developed world. Boosting the strategic agricultural sector policies by triggering the process of large-scale production and commercialization of agricultural commodities with a competitive advantage that directly offers to lead economic, social, and environmental gains, in the long run, is much necessary.

Despite the significant roles of agriculture, North-Western Nigeria lags in many global economic indicators amidst population pressure compared to the West Region of Romania. This has unpleasant implications for food insecurity, widespread poverty, and sustainable economic development.

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DEARTH OF WATER: THREAT TO HUMAN HEALTH IN BANGLADESH AND NIGERIA

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ABSTRACT

Nigeria and Bangladesh are both developing countries, each with its challenges. Although, apart from their major differences, there is one key similarity both countries have, and it involves dearth of water which caused by pollution. Water pollution occurs when unwanted materials with potentials to threaten human and other natural systems find their ways into boreholes, lakes, rivers, streams, wells, or even reserved fresh water in homes and industries. The pollutants are usually microorganisms, sand and various forms of deposits such as sewage materials, plastic, rusted metals, used paper, automobile parts and emission from vehicles, chimneys, lastly, disposed foods. Some of which are decomposed by the action of micro-organisms. This paper focuses solely on the scarcity of water, causes, effects and ways of alleviating water pollution in Nigeria and in Bangladesh.

Keywords*:* Water-Pollution, Causes, Effect, Human Health, Alleviation

INTRODUCTION

Water is life and clean water means health. This is because it acts as both a solvent and a delivery mechanism, dissolving essential vitamins and nutrients from food and delivering them to cells. Besides the above, the amount of water used for other purposes varies widely, and is greatly influenced by the type and availability of water supply (Hofkes, 1981). Water is required for drinking, cooking, recreational activities, farming, fishing, making them unavoidable for the evolution of society and civilisation (Orubu, 2006). Okafor (2016) also asserts the importance of water to aid our daily activities. Presently, there is a growing dearth of fresh water evident in many parts of the world but emphasis will be on two third world countries. This includes Bangladesh and Nigeria.

Bangladesh, one of the most densely populated countries, facing severe water pollution and scarcity. Although 97% of the total population has access to water, the quality of water is always questionable (WHO, 2018). Bangladesh consists of more than 230 large and small rivers but these rivers are now choked by the pollution caused by mainly human intervention (Majumder, 2009). In Bangladesh, there are frequent extreme events like flooding and cyclones that destroy sanitation facilities, cause toilets to overflow, and contaminate drinking water sources. Drinking water from natural sources in coastal Bangladesh has become contaminated by varying degrees of salinity due to saltwater intrusion from rising sea levels, cyclone and storm surges, and upstream withdrawal of freshwater. Also, Underground water is not also safe as the threat of arsenic contamination is very high all over the country. This could lead to waterborne diseases thereby damaging the health and good well-being of the public. According to Flanagan et al (2012), 97% of the total population in rural areas depend on the tube wells for drinking water. As a result of the above, 35 - 77 million individuals have been exposed to arsenic contamination.

In Nigeria today, majority of the common fresh water sources such as, taps, wells, streams and springs have been polluted, resulting to serious outbreak of typhoid, dysentery, cholera, hepatitis and many more not discussed in this study. According to the United States Agency International Development (2021, p.4), water stress is the highest in north-eastern Nigeria and driven by growing surface water demand for irrigation and municipal use. Also, oil spills have severely degraded the Niger Delta and threaten public health. This has also decreased fishery production and aquatic biodiversity says USAID. The Nigerian Government and UNICEF on the 22nd of March 2021, released a WASH NORM study which showed that while there has been some progress, thanks to efforts by the Ministry of Water Resources and its partners to strengthen the sector's planning and monitoring, there is still much more work to be done in the country to ensure that all Nigerians have access to adequate and quality water and hygiene services.

Figure 1. Tap water supply in Nigeria.

Figure 2. Tap water supply in Bangladesh.

Global Water Crisis

Globally, the current water supply picture has been alarming despite the unprecedented advances in the last decades. Fresh water supply is facing intense and unsustainable demand from users of all sorts including farmers, which have to compete for water with urban dwellers and industries. A situation of total lack of water, which may prompt a country to go to war to acquire streams or rivers, is not very far in sight. In the Sahelian region and drought prone areas of the globe, there is a strong association between water availability and foods production. (Augustine, Zachariyau, Olarunda, et al., 2009) It is an undeniable fact that poverty undermines provision of good water supply.(Raimi, Olalekan, Oluwaseun Emmanuel, Nimisingha, et al., 2019; Olalekan, Omidiji, Williams, et al., 2019) Moreover, lack of essential benefit of hygiene, sanitation, water and hygiene to all persons remains a barrier to growth, and a root cause of unending poverty.(Raimi, Olalekan, Oluwaseun Emmanuel, Nimisingha, et al., 2019; Olalekan, Omidiji, Williams, et al., 2019) If good water is synonymous with developed societies, then little or lack of it or poor quality is associated with poverty and deprivation, which is the bane of the third world countries.(Olalekan, Omidiji, Williams, et al., 2019) That is why most of the poor people in the world are frequently sick as a result of unwholesome water utilization and poor hygiene.(Raimi, Pigha, Ochayi, 2017) Since life expectancy is a cumulative event in an environment, the shear sustained frequency of childhood diseases and afflictions occasioned by malnourishment, poor mental and physical development and timely death stem from poor hygiene and contaminated water.(Raimi, Olalekan, Oluwaseun Emmanuel, Nimisingha, et al., 2019; Sodhi, 2005; Raimi, Pigha, Ochayi, 2017; Olalekan, Omidiji, Williams, et al., 2019; Augustine, Zachariyau, Olarunda, et al., 2009).

As the world commemorates World Water Day, on the 22nd of March, globally, more than 1.42 billion people, including 450 million children living in areas of high or extremely high-water vulnerability, according to new analysis released by UNICEF. This means that 1 in 5 children worldwide does not have enough water to meet their everyday needs. The figures in Nigeria are particularly worrying, with 26.5 million Nigerian children experiencing high or extremely high-water vulnerability. The analysis, part of the Water Security for All initiative, identifies areas where physical water scarcity risks overlap with poor water service levels. People living in these areas depend on surface water, unimproved sources of water, or water that can take more than 30 minutes to collect. According to Peter Hawkins, UNICEF Representative in Nigeria, “The world's water crisis is not coming - it is here, and children are its biggest victims,". Almost one- thirds of the globe still resides in squalid environments, smell and disease at the doorstep and being imprisoned by hygiene related illness and ignorance. (Raimi, Olalekan, Oluwaseun Emmanuel, Nimisingha, et al., 2019) These are also countries of high population growth rates. Economically, the poor are still spending more on hygiene-related and water-borne diseases, weakening more ill economic indices and perpetrating continuous poverty. It is expected that more funds be committed to water development projects particularly in the third world countries and the significance of water assets as a defense against universal poverty should remain more effectively addressed. (Augustine, Zachariyau, Olarunda, et al., 2009).

Also, the new analysis released by UNICEF in 2021 also proved that sustainable and equitable access to safe drinking water remains a challenge in Nigeria, with over 86 per cent of Nigerians lacking access to a safely managed drinking water source. The problem is compounded by poor drinking water quality and lack of equity in access. Although about 70 per cent of Nigerians are reported to have access to a basic water service, more than half of these water sources are contaminated. And although 73 per cent of the country’s population have access to a water source, only nine litres of water on average is available to a Nigerian daily. While the impact of water scarcity can be felt by all, no one suffers more than the most vulnerable children. Children and families living in vulnerable communities face the doubleedged sword of coping with high water scarcity levels while having the lowest water services, making access to sufficient water especially susceptible to climate shocks and extreme events.

Causes of water pollution

Water pollution is caused due to several reasons such as, sewage and solid waste, junk and water misuse of family units, horticultural grounds and release of processing plants into lakes and Rivers. These wastes contain unsafe chemicals and poisons which make the water toxic for oceanic creatures and plants. According to Arman & Avijjit (2018), below are forms in which water is been polluted in Bangladesh.

- **Inadequate Sanitary Facilities**

Lacking sanitation represent a genuine natural risk of water pollution in Bangladesh. Dhaka Water and Sewerage Authority (DWASA) can serve just for 15 to 20% of city population. Without the sanitation and infrastructural administrations, 40% having septic tank and douse pit, 15% utilizing pit latrines and 30% utilizing open toilets. The sewage is for the most part discharged into low-lying territories and the untreated water causing incredible natural risks [Faisal, Shammin, Junaid, 2001].

- **Arsenic Contamination of Ground Water**

According to data retrieved from Arman & Avijjit (2018, p.108), Arsenic in ground water imposes a genuine natural threat for Bangladesh. Around ninety-seven percent (97%) of Bangladeshi individuals have been utilizing ground water as the primary source of drinking water yet the water has been undermined by arsenic sullying. The greater part (52%) of the considered population drink well-water containing >50ug/L of arsenic and more than 66% (70%) drink well-water containing > 10ug/L of arsenic. The satisfactory level of arsenic in drinking water is 0.05 mg/L for Bangladesh yet in few regions, it is discovered more than 70 times higher than that standard. Around 80 million individuals are at a danger of arsenic defilement.

- **Oil Spill Based Water Pollution**

River water gets contaminated because of oil spilled from boats and tankers while traveling around. The spilled oil does not break up in water and structures. In Bangladesh, mixing of oil in the river water is the main reason of river water pollution. This is also a major environmental problem in Nigeria as it poses much threat to life than poverty to the extent that rain water is no longer fit for human consumption due to the contamination of rain (acid rain) and ground water by the activities of Nigerian Liquefied Natural Gas Company (NLG) in Bonny, owning to gas flaring and other oil companies.

Government approach to this problem is most worrisome; excessive bureaucracy is weighed down their approach. Thus, their environmental policies have not been implemented to the latter. According to Galadima, Garba, Leke, Almustapha, & Adam (2011, p. 13), the duty of the Federal Ministry of Water Resources is to provide safe water to the people but the Niger Delta people in the environmental impacts assessment (EIA) carried out on the 10th of August, 2017, shows that water pollution has hampered rural economic activities and posed as a major threat to sustainable development. Reports from experts have declared both ground water and rainwater unsafe for consumption.

Other causes of Water Pollution in Nigeria are;

- **Home Based Water Pollution**

In Nigeria, some persons do not care how they dispose of trash. Due to this, it is not surprising that heavy rainfall sweeps this dirt into drainages and ends up blocking the channel. For example, Lagos with over 12 million individuals does not have a central sewage system but rather all waste is emptied into a lagoon. This same lagoon and the sea around is the source for most of the fish that the city consumes. Land disposal of solid waste creates an important source of ground water pollution. The problem of pollution from refuse heaps is greatest where high rainfall and shallow water table occur. Important pollutant frequently found in leachates from refuse dump includes BOD, iron, manganese, chloride and nitrate (Krist, 2000).

Also, some environment situated in Nigeria is suffering from urban sprawl and this has resulted into lack of a proper drainage system. Lack of a proper drainage system could lead to serious flooding problems even with minimal precipitation. Also, only toilet waste is discharged through a septic system in most houses. Majority of the houses even lack indoor plumbing thereby resulting to fetching from neighbouring taps or wells while some still fetch from the stream depending on how exposed the area is.

- **Local Market Induced Water Pollution**

Local markets such as, shops, super markets, road side markets constitute more than 90% of the markets accessible to most people in Nigeria and different wastes are dumped in rivers, lakes, hand dug wells and reservoirs used by people as sources of household water. These waste include, cans of soft drinks, fruit peels, wrappers of consumables, blood, faeces, intestines from animal slaughtered. Nwanta et al. (2010) reported that a total of 194 kg of solid waste is generated daily in Nsukka metropolitan abattoir, without any hygienic disposal or management system. Further studies on the waste raised serious public health concerns, as bacteria such as E. colli, Bacillus sp, and Staphylococcus sp. were frequently detected.

Effect of Water Pollution on Both Countries

There is a clear link between water pollution and health issues. Pathogens are disease-causing bacteria that transmit disease directly among humans. Many water-borne diseases are being passed from person to person. Extreme weather is linked to heavy rains and floods, which result in a variety of diseases in both developed and poor countries. Many aquatic infectious diseases are linked to fecal contamination of water sources, which leads to infection via the fecal-oral route. Different ailments such as respiratory disease, cancer, diarrheal disease, neurological condition, and cardiovascular disease are among the health risks connected with polluted water. Cancer and blue baby syndrome are caused by nitrogenous substances. Because of poor sanitation, hygiene, and water availability, poor people are more susceptible to disease. Contaminated water has serious consequences for pregnant women who are exposed to chemicals; it increases the rate of low birth weight, which has a detrimental impact on fetal health. Water of poor-quality damages crop production and infects our food, posing a threat to aquatic and human life Efficacy (2009).

SOLUTION TO WATER CRISES IN NIGERIA AND BANGLADESH

Despite 663 million people lacking access to clean water, remarkable progress has been made in the last 20 years. There are lots of different innovative solutions and tools to tackle the water crisis. One of the most common and sustainable ways is the creation of hand pump borehole wells, which do not rely on any external source of power (Thirst Project, 2015). Another useful tool are the bio-sand water filters. Due to geological factors (i.e., arsenic presence), installation of wells is dangerous in certain areas hence, many communities must use water from unprotected surface reservoirs. In situations like this, different solutions are available.

Consumers resort to filters which filtrate out any contaminants from the water. Also, they can use the recently developed Water Seers, which use the surrounding environment to extract water from the atmosphere (Spinks, 2018) instead of underground. Further methods, proven to be successful, are the implementation of Fog Catchers to capture moisture and, consequently water (after the condensation process), and the application of Rainwater catchment systems.

Other solutions that would aid alleviating water crisis in the above countries are;

❖ **Inventing new water conservation technologies**

In the areas where the aquifers and wetlands are disappearing and where the rainwater is acidic and becomes more and more unpredictable, there is need for more creative and innovative ideas to solve water crisis. But while we are trying to cope with the shortage of fresh water and to develop conservation technologies, energy consumption is an important factor to take into account. Another feasible strategy is to use water resources more efficiently. This is particularly important, since a number of studies show that local overexploitation is in most cases a far more significant cause of water scarcity than climate change. UNESCO’s World Water Development Reports, for example, identify many possibilities for using water more efficiently, while access to technological innovation in poorer countries continues to play an important role.

❖ **Recycle wastewater**

Recycling more water will help us reduce water waste and increase reserves. In March 2021, World Water Day speakers recommended a new state of mind for wastewater treatment. Some countries, such as Singapore, try to recycle to reduce water imports and become more self-sufficient. The rich republic of East Asia plays a leading role in the development of a leading technology that cleanses wastewater for other purposes, including beverages. If both Nigeria and Bangladesh can cultivate the above method, then there could possibly be a slight chance of increase in water.

❖ **Address pollution**

Water pollution is a great disaster to both Nigeria and Bangladesh citizens as it underpins every aspect of human and environmental existence. These water pollutants that human and environmental existence can be human induced and natural However, the pollution of water occasioned by oil spillages and oil exploration activities is the most important and damaging in the affected region (Niger-Delta). Since massive water pollution reduces production of farming and economic growth, measuring and maintaining water quality is essential to human health. The severe water challenges facing the world today requires an unprecedented global response.

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STUDY OF DRINKING WATER CONSUMPTION PATTERNS OF CONSUMERS

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ABSTRACT

The aim of the study is to examine the drinking water consumption habits and the factors influencing it among the Hungarian population. The questionnaire was filled in by 215 people from 5 counties (Békés, Csongrád-Csanád, Jász-Nagykun-Szolnok, Bács-Kiskun and Pest counties). The results show that water consumption is most affected by ambient temperature and physical activity, and women consume a higher proportion of mineral water than men. Considerations when buying or choosing mineral water include the price and taste of the product, as well as a clear ranking of favourite mineral water brands.

Keywords: tap water, mineral water, consumption pattern, ambient temperature, brand loyalty

INTRODUCTION

Appropriate hydration is essential for health and well-being. In Europe, water consumption patterns vary despite the unlimited availability of this resource. Water constitutes the largest proportion of total fluid intake in most countries (Elmadfa – Meyer, 2015).

Free access to drinking water is an essential condition for a lasting human presence in certain geographical areas. However, good quality drinking water that is safe to consume is not available to everyone. In some areas of Canada where the supply of safe drinking water is unresolved, the consumption of bottled water is significantly higher than in parts of the country that are supplied with tap drinking water (Spicer et al. 2020). This work demonstrates how ensuring access to clean drinking water is not simply a technical issue but requires consideration of the socio-cultural, economic and political factors that shape water quality as well as individual risk perception.

European nutrition surveys generally report an average fluid intake within the recommended range of 1.5–2.0 litres/day, with higher intake levels corresponding with increasing frequency of intake. However, some population groups consume less than others, e.g., the elderly who are at higher risk for dehydration. In turn, physical activity is associated with higher beverage consumption as is adherence to a health-conscious diet. While water constitutes the most commonly consumed beverage throughout Europe, drinking patterns and quantities vary and are influenced by several factors, including age, gender, diet, and physical activity level (Elmadfa – Meyer, 2015). The recommended daily fluid intake is 2.7 litres/day for women and 3.7 litres/day for men (Pozsár et al. 2019).

Total water consumption is influenced by a diverse set of climatic, socioeconomic, demographic, policy and landscape factors. Climatic variables could be the temperature (maximum daily, average daily, average monthly and minimum daily); precipitation (amount, frequency and duration); RH; wind (speed intensity, frequency and duration); etc. In addition to climatic, the most important variables are demographic changes, the availability of water resources, income, the price of water, people's habits and several others (Dimkic, 2020).

Recommendations are divided as to how much fluid to take in a day, but are usually made to a minimum of 2 litres. Only a third (33.53 per cent) of university/college students agree, with the rest consuming less fluid. Water is very popular, with 22.9 percent consuming more than a liter and a half a day (Papp-Váry – Schwang, 2012). However, there were 7.14 percent who responded that they do not drink water at all. College students are drinking fewer fluids than they would need for a healthy lifestyle. This is especially true for women.

By the results of Vieux et al. (2020) water intakes are followed distinct social gradients. Most tap water was consumed by higher-income groups. Non-Hispanic White groups increased tap water consumption. Non-Hispanic Black and lower income groups increased bottled water, not tap. Conclusion: The opposing time trends in water consumption were not uniform across age groups or sociodemographic strata. Lower-income and minority groups consumed relatively little plain drinking water from the tap.

The order and relative proportions of the mineral water selection aspects of young people studying in higher education are as follows: brand (35.17%), price (31.19%), total mineral content (19.66%) and packaging (13.99%) (Sipos et al. 2007).

In the European Union, almost 84-85% of the turnover of bottled water is natural mineral water, 11-12% is spring water and only a few, 3-4% is table water. These ratios have been essentially stable since the turn of the millennium, with the exception of a few tenths of a percent change. Consumption of table water alone fell by 0.6% between 2001 and 2006. The role of carbon-free waters is strengthening in its tendency, compared to CO_2 enriched waters by 56%-44% (Sipos, 2009).

Inorganic salts can be obtained from mineral waters by the living organism. While taps with a mineral content below 1000 mg/liter meet the drinking water standard, mineral waters can have values up to 3000 mg/liter (Nagy, 2012). For example, the components of tap water in Debrecen are between the lower and upper limits for mineral waters. Examined from a professional point of view, it can be stated that the public water supplier of Debrecen and its region supplies mineral water quality products to households.

The beneficial effects of drinking cures are obvious. The beneficial therapeutic effects have been confirmed by both centuries of traditional experience and modern medicine. As these effects are primarily related to the composition of the medicinal water and only secondarily to the drinking conditions, the grouping consists of the dominant components of each water type. A “drinking cure” without a specialist - despite all your well-intentioned efforts, you may not know all the indications, the exact composition of the water consumed, or the least of the contraindications (Némedi, 2007). There remains a fixed myth about the “benefits” of drinking cure. Not only has the consumption of chlorine-free bottled water become fashionable, but it has become a way of life. Of course, the global market approach prevails here as well, and the medical aspects that would be relevant in our field (drinking cures) are also pushed into the background. The unsorted and excessive consumption of mineral water can have an effect contrary to the original intention of the consumer. Several examples of this could be mentioned (excess fluoride intake, sodium overdose, radioactive waters, carbonated water, foreign bottled waters of unknown composition, etc.).

High intake of fruit juices and soft drinks contributes to excessive weight gain and obesity in children. Furthermore, parenting practices play an important role in the development of children’s dietary habits. The consumption of water was inversely associated with that of soft drinks but not with the consumption of fruit juices. The child’s water intake was favourably influenced when stricter parenting practices towards soft drinks were adopted (e.g., less parental allowance, low home availability and high parental self-efficacy in managing intake). There was less influence observed of parenting practices towards fruit juices. Fruit juices were consumed more often than soft drinks (Mantziki et al., 2017).

By the results of Gibson – Shirreffs (2013) Total beverage consumption was higher at weekends, especially among men. Overall, beverages supplied 16% of respondents (men 17%, women 14%), alcoholic drinks contributed 9% (men) and 5% (women), milk 5-6%, caloric soft drinks 2%, and fruit juice 1%.

Regarding the harmfulness of energy drinks, the majority of respondents (59%) say that energy drinks are mild, 19% think they are very harmful, 9% say they are not harmful at all, and 13% cannot decide whether they are harmful. It is important to note that 22% of those surveyed believe that energy drinks are ineffective and 19% think they are very harmful, but still consume them (Orgovány, 2012).

MATERIALS AND METHODS

A questionnaire survey was conducted among the Hungarian population. The online questionnaire contained 20 questions, 6 of which related to demographics and the rest to drinking water consumption patterns. The responses received were filtered for 3 age groups and 5 counties, so the data of 215 fully completed questionnaires were processed.

The preliminary study was limited to presenting the distribution of responses especially women's ones. Statistical analysis is possible after reaching a larger number of samples after continuing the work.

RESULTS

Due to the low sample size, the results are not representative. The majority of respondents were women, with only 8.37% being men. Nearly three-quarters of the respondents were in the 20-50 age groups (*Figure 1)*.

61.11% of men consume more than two litres of water per day, while the most populous group (44%) of women consume only 1-2 litres (*Figure 2-3)*. For the total 30-40-year-olds, the rate of water consumption is not very good from a health point of view, as 23% of them do not drink 1 litre per day. It is unfortunate that the older age group considers it less important to consume more than 2 litres of fluid a day, because for physiological reasons they might need it the most (*Figure 4).*

Interestingly, the espresso coffee or cappuccino consumed daily was not counted among the liquid intake. 15.22% of women say they only drink tap water, while 51.51% drink bottled water/mineral water (many of them could not define the concept of mineral water) as well as tap water. Most of this ladies ranged in age group from 40 to 50 years. 22.86% of respondents prefer only mineral water.

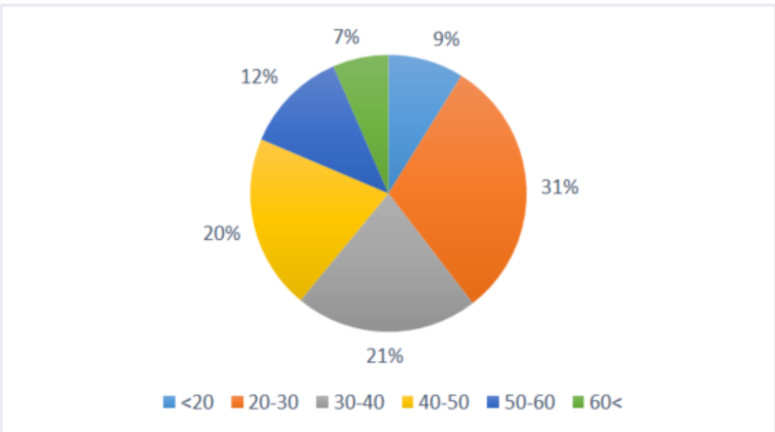

Figure 1: Proportion of age groups among respondents
(Legend: age in years)

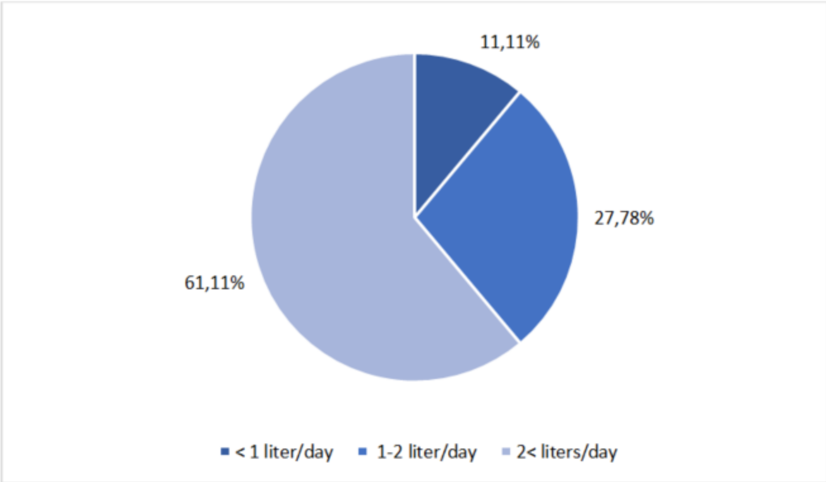

Figure 2: Men’s daily water consumption

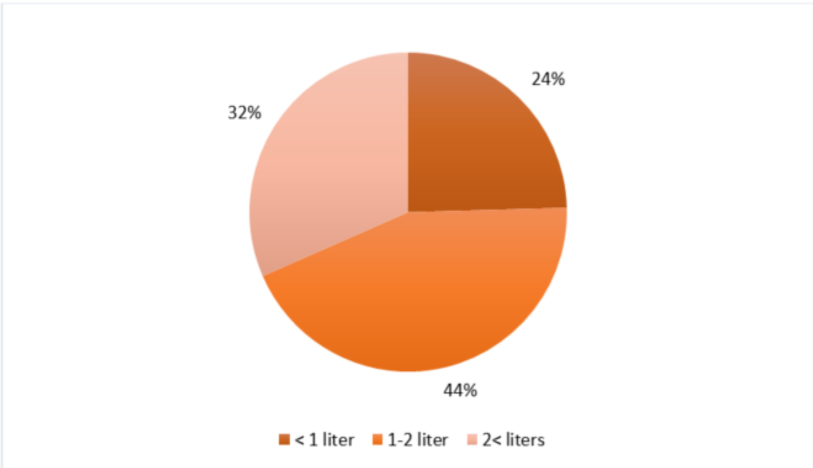

Figure 3: Women's daily water consumption

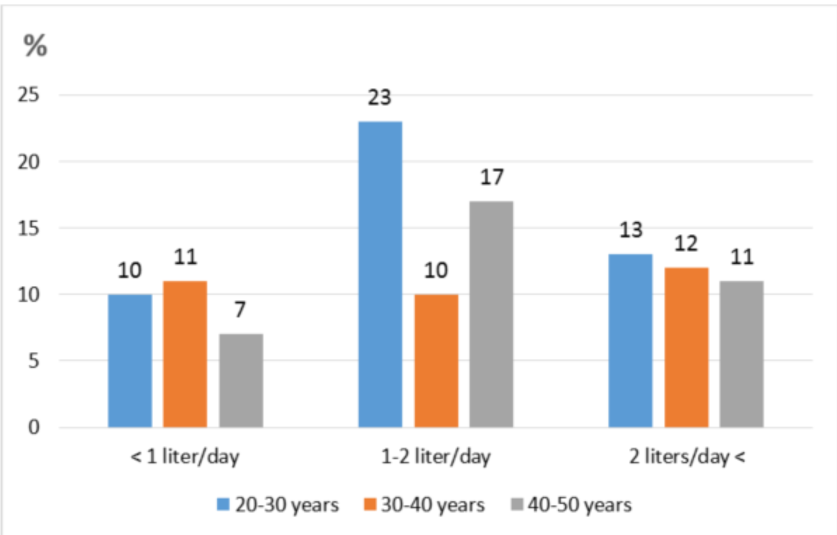

Figure 4: Women's daily water consumption by age group

Regarding the current analysis, the environmental temperature and physical activity have the greatest impact on the amount of water consumed (almost 29.34% and 28.1%, respectively), which means that these two aspects are the most significant factors (*Figure 5)*. After that, the diet - more precisely e.g. the effect of consuming a diet rich in salt or protein - was reported at 23.97%. Based on the responses, only 13.22% feel that the season has an effect on fluid intake and only 3.72% of ladies are affected by weight loss or weight gain. Responses have also been made to the other category, according to which breastfeeding is a very important factor for expectant mothers. There was an older lady who described in the other category that her water intake was not affected by anything, so they regularly consume the same amount on a regular basis, regardless of any outside influences.

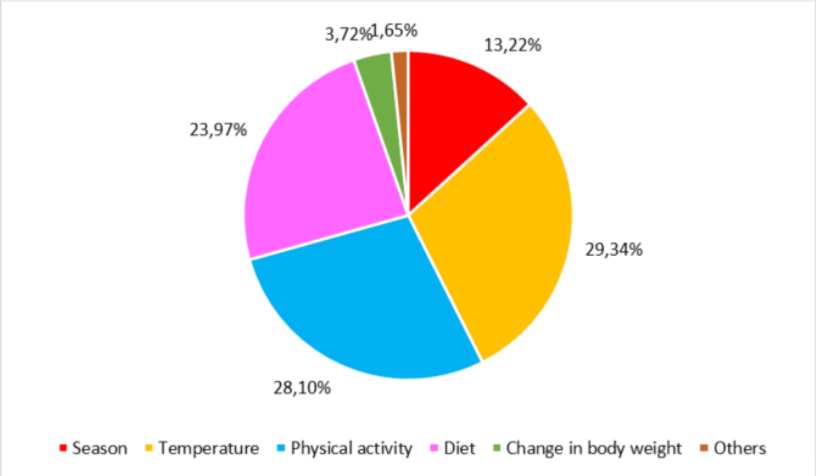

Figure 5: Distribution of factors influencing water intake

Among the factors influencing water consumption in men aged 20–30 years, ambient temperature and diet were the most characteristic factors based on the indications, followed by physical activity. Seasons and other categories are not indicated.

The questionnaire also covered the type of mineral water purchased and the preferred brand, as well as the external influences on which people choose mineral water. Of the ladies in the youngest age group, 7 do not consume mineral water, and most of them prefer still water, which is a distribution of 67.39% within the sample, and the rest prefer sparkling water. In the case of those aged 30-40, it can be said that non-carbonated water is preferred by many, and only 3 people prefer sparkling water. Still water is also more popular among the 40-50 age group, according to the ladies, but here carbonated water was already marked with a higher proportion of 28.57%, and 6 stated that they do not consume mineral water at all.

The range of factors influencing the choice was an open question. Among the factors considered when purchasing, responses from the 20-30 age group dominated the taste and price of the product. For some ladies, availability is important and mineral content is considered important. For some, brand awareness is important. The recommendation of others affected only 2 people. In the sample of 30-40 year olds, 42.85% of the ladies taste the product in the most important choice as well as the mineral content is taken into account. In contrast, the price of a product received the most votes among 40-50 year olds, as did its taste, so these two factors seem to dominate this issue. No one in this age group is affected by the recommendations of others. The summary of the share of answers to this question is shown in *Figure 6*. The advertisements had no effect on anyone.

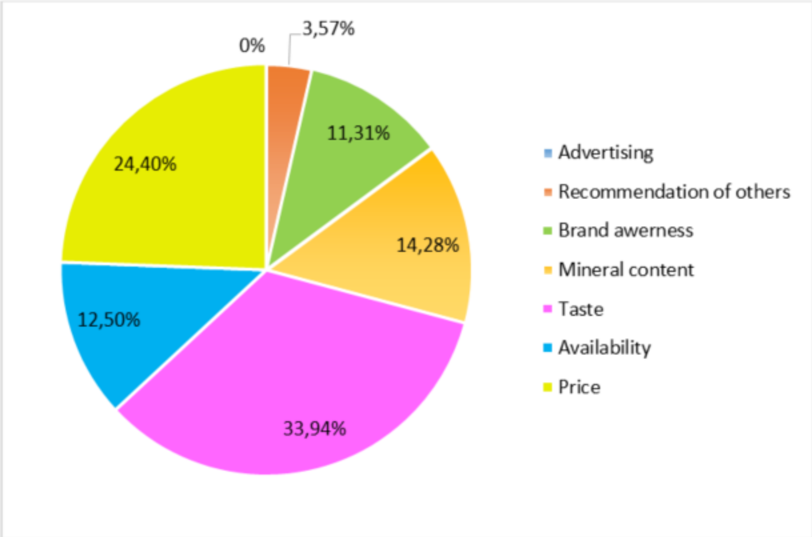

Figure 6: Distribution of factors influencing product choice

In addition to those listed for the open-ended question about your favorite mineral water brand, 17 other brands were listed in the other category. Several also mentioned consumer brands that are multinational companies' own branded products. Based on the answers of the 20-30 age group, it can be said that this age group likes Szentkirályi mineral water the most, 34.54% of the respondents voted for this brand. Second place went to Natur Aqua, followed by Nestlé Cédrus Aquarel. Even in the case of 30-40 year olds, Szentkirályi mineral water is the most popular, and the votes for the other brands were almost the same. Natur Aqua is also ranked second with Nestlé Cédrus Aquarel in third. None of the participants in this age group consumed Kristályvíz and San Benedetto, however, the Theodora was also marked by only 1 woman. The 40-50 age group also likes the Szentkirályi the most, Natur Aqua is also in second place and Nestlé Cédrus Aquarel is again in third place. In the other category, Mizse seemed the most popular. San Benedetto, Theodora and Vöslauer did not receive votes in this case. The distribution of responses by brand is shown in *Figure 7*.

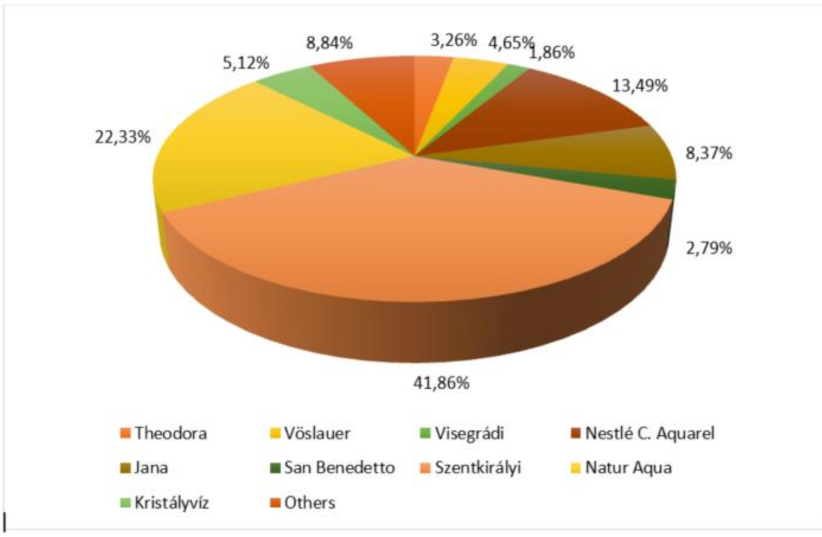

Figure 7: Consumption rate of popular mineral water brands

Among the water-replacing drinks chosen as thirst quenchers, fruit juice proved to be the most popular drink among 20-30 year olds. At the same time, many people like to drink carbonated soft drinks (syrups diluted with sparkling water are also included). Energy drinks, beer and wine barely received a vote. Nearly 20% of respondents like to drink hot and cold tea (*Figure 8)*. It was surprising that for 42.85% of the 40-50 years age group, carbonated soft drinks are the most popular drink, followed by fruit juice.

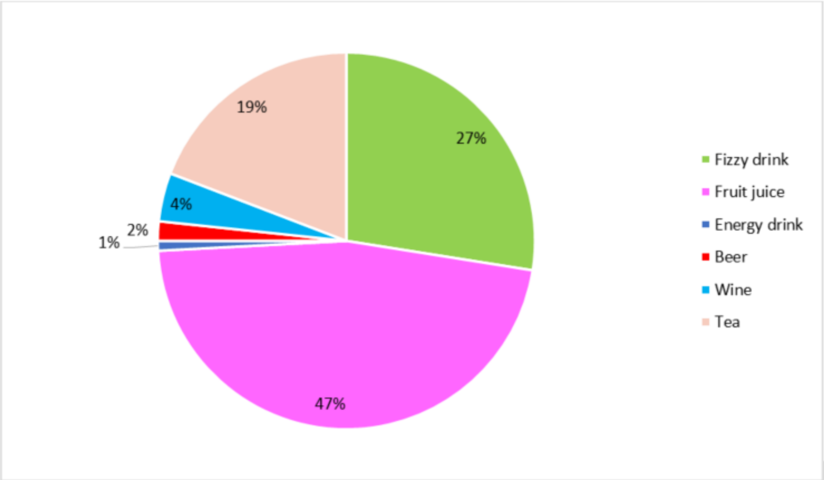

Figure 8: Distribution of substitute drinks among women

CONCLUSION

- Based on the results, it can be concluded that the sample population does not consume enough water, big part of the consumers drink less than 1 litre of water per day, and the vast majority, 56.28%, drink between 1-2 litres per day. Only 34.88% of them have a water intake in excess of 2 litres per day.
- The factors most influencing water consumption are ambient temperature and physical activity.
- Women consume more mineral water (sparkling and still together) than men.
- Sparkling waters are much more preferred by people than still ones.
- Mineral water selection considerations are primarily price and taste.

The results reflect preliminary study data and are not representative. In order to achieve a larger sample size, the survey will continue.

Acknowledgments

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METABOLIC WATER IN ANIMALS' ORGANISM

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ABSTRACT

Fluids and electrolytes plays a very important role in animals' metabolism. Estimated water quantity in the organism of a healthy adult animal is about 60%, being related also by species, age, but also by gender and body composition. Thus, the quantity of metabolic water produced of catabolism of 100 g carbohydrates, 100 g lipids and 100 g proteins is about 200 g. The water is distributed to intracellular (about 40% of body weight and 2/3 of total body weight) and extracellular compartments (about 1/3 of total body weight). The optimum balance between the input and output water is possible by water homeostasis, and is also influenced by different animal, environment, feed plan, and health status of animals, being a very important issue in animal production. Metabolic water is produced mainly by electrons transport chain and oxidative phosphorylation process, which involve in principal the catabolic processes of carbohydrates, lipids and proteins – nutrients from food and feed with energetic role in organism. The endogenic water is possible by the hydrogens transport in respiratory chain and oxygen molecule, which finally form the water molecule.

INTRODUCTION

One of the worldwide major problem is the environment quality, but the main concern is the water supply for every single living creature. Thus, if we would talk about the animals that are the most resistant animals regarding the water needs, for sure we will think at camels. But there is one animal that really breaks the record for water consumption and puts the camels in a lower position when it comes to the need for exogenous hydration. That animal is the *Dipodomys microps*, kangaroo rat – an American Southwest rodent, that can live entire life without even drink any drop of water (Longland and Dimitri, 2021). Why is very important this example regarding the subject of our study, because it explains and demonstrates that animals' metabolism is so performant that is capable to produce by biodegradation and biosynthesis the water needs for a certain period of time – period that is depending on the animal species (Abir-Awan et al., 2019).

Life is directly related to the exogenous and endogenous water and dry matter quantity and quality, but water needed in a living organism is on the foreground compare with other matters.

Water is used in the organism as a powerful solvent for ionic and neutral molecules, strongly influence the dissociation state of macromolecules; as a supporter of cellular structure, as a transporter of solutes, and also is used for body temperature regulation (Matkov, 2018).

Human and animal organism contain different water proportions, depending of many factors, by one of the most important is age! So, the fetus's body contains about 90% water, the newborn baby's body contains about 80% of water, a child's body contains approximately 70% water, an adult's body contains between 60-65% of water, while an elderly person's body contains only about 55% of water. On the other hand, tissues from human and animal organisms contain different percent of water (figure 1). Usually, the distribution of water in human organism differs between genders: men have between 55-70% water, while women have 45-60% water. Obese people or animals have less water distribution in the organism.

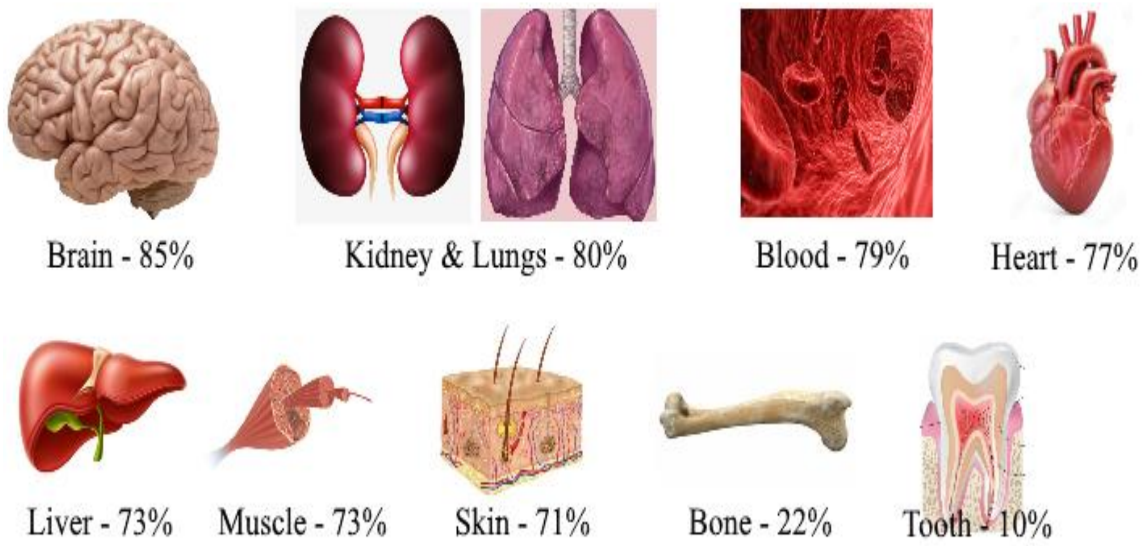

Figure 1. Water distribution in different tissues

Total water of body weight represents 60%, intracellular fluid contain 40% water, extracellular fluid has 20%, interstitial fluid contains 15% water, and plasma contains only 5% of water. Endogenous water represents the water molecules produced in animals and human organism following different biochemical reactions, usually in anabolism of complex molecules. Also, water endogenous quantity released as metabolic water after nutrients catabolism is depending of the type of macronutrient, and the yield of water produced by oxidation is different because 100 g of carbohydrates release 60 ml of water, 100 g of proteins release 40 ml of water, while 100 g of lipids release 110 ml of water, and for 1000 calories consumed by human or animal organism is necessary about 125 ml of endogenous water (Abir-Awan et al., 2019; Delgado et al., 2013; Martinez-Martin et al., 2017; Sachs and Sivaselvan, 2015; Widmaier et al., 2008).

There are various chemical substances and characteristics which regulate the water intake and excretion, but this two processes are responsible for liquid balance and health status in organism.

Water biochemistry

Water molecule is very simple polar molecule, being composed of two positively charged hydrogen atoms bind of a large negatively oxygen atom, and the differential charge due to polarity which mandate the water interactions. This property leads to specific interactions with other molecules, but the best are interactions with other water or polar molecules. The interactions can be explained by the double charge of the molecule – a positive and two negative charges – and each charge side attracts the molecules with opposite charge. The bonds formed between water molecules are relatively strong connections that lead to cohesion property – which helps animal and plant cells to take up water molecules and also is important to the high boiling point of water – a property that helps animals and humans in water homeostasis (Ho, 2016; Hoffman and Pedersen, 2011). Water structure and molecules arrangement is depending on the physical state of water: solid, liquid, or steam phase – figure 2 (Alberti, 2017; Hulea and Ahmadi, 2021).

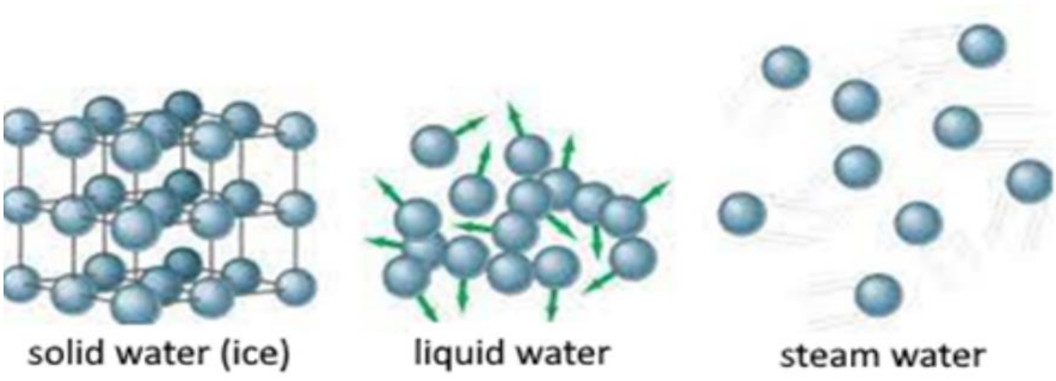

Figure 2. Different physical states of water molecules

Also, the water molecules have electrical polar asymmetry being surrounded by positive and negative regions that move and hit the molecules leading to the effectively breaking of molecules that cause dissolving of other polar molecules (ex. sucrose) or ionic molecules (NaCl). Thus, water molecules as solvent of gases, solids and liquids help the cell in the transport and use of substances, no matter if the substances are nutrients, drugs or potential toxicogenic substances.

Biological roles of water in organism

All living organisms are severe dependent of water intake, endogenous and exogenous. For humans and most of animals, a loss just of 4% of total content of body water leads to dehydration, while a loss of 15% most of the time is fatal! The need for water is related to many aspects (species, health status, environment conditions, physical activity), but there is no term to compare the need of water with that of water, because the water is vital for survival!

Due to the intracellular and extracellular composition of the cell, the pressure exerted on the cell membrane is dependent on the degree of cellular hydration, which maintains the shape and structure of the cell so that proper hydration ensures the optimal functionality of the cell. Thus, in well hydrated cells the pressure inside the cell is higher compared to the outside pressure of the cell, while in dehydrated cells the pressure inside the cell is lower compared to the cell outside pressure, that lead to deforming the cell shape and functionality (Bray et al., 2010; Delgado et al., 2013; Groot and Grubmüller, 2001).

From other point of view, the cells membrane is formed by two layers of phospholipids - that have one polar "head" and one nonpolar "tail". The polar head of the phospholipids interacts and attracts the water molecules, while the nonpolar tail avoids and repulses the water molecules. This property is essential for the selectivity transport of the cell membrane by penetration and crossing of specific substances like salts and nutrients that enter and exit of the cell. Without optimum hydration, the cells membrane wouldn’t be able to keep the shape and function, so the balance and the composition of the cells could be seriously affected and it could be possible that the cell membrane to be unable to keep inside the cell, important molecules (Koivusalo et al., 2009; Lloyd, 2013).

Metabolic water in living organisms

To bind amino acids forming peptide bonds, to bind mono-carbohydrates forming poly-carbohydrates, to bind fatty acids and alcohols forming complex lipids, it is necessary to release water molecules for each bound. And in reverse, to break down the peptides and proteins, poly-carbohydrates and complex lipids are necessary to consume water into reaction. These are metabolic reactions that play with water molecules, making water being indispensable for life.

From all nutrients, the peptides and proteins, and also their additional components like hormones, enzymes and nucleic acids (DNA and RNA) are depended on water. The structural components of proteins are the amino acids which forms peptide bonds building up blocks that are folding into specific pleated sheets shapes – which are responsible for receiving and sending signals, catalyzing biochemical reactions, preserving and transmission of the genetic characteristics. Water molecules surround DNA double-helix conformation, preparing to encode and decode the genetic information, being responsible for passing the information onto new cells due to the growth, developing, reproducing, renewing, replacing, surviving and cell prosperity (Khesbak et al., 2011; Saragovi et al., 2022).

The bond water sheath is very important for hydrogen bounds between the nucleotides from the helix-structure of DNA. The water is responsible for a precise switching function in DNA because the researchers' results indicate that even increasing the hydration rate by only two water molecules for each phosphate group may lead to an instant fold of the DNA structure. This property is very important because it may be used to control different processes, such as the release of various active agents or compounds from DNA-based produce (Khesbak et al., 2011).

One of the major metabolic pathways of water formation is the electron transport chain and oxidative phosphorylation. Oxidative phosphorylation is a very complex biochemical process from the mitochondrial inner membrane, based on a series of specific proteins and electron carriers. The flow of electrons from the mitochondrial membrane allows the electron transport chain to act as a proton pump. Thus, protons accumulate in the membrane and create a driving force (an electrochemical pressure), with the help of specialized protein complexes, which capture the energy provided by protons as they advance to the other side of the mitochondrial membrane. The stored energy is then used to chemically bind a phosphate group in the adenosine diphosphate (ADP) molecule to form adenosine triphosphate (ATP), which comes in and completes the oxidative phosphorylation process (Buck et al., 2017; Ferrier, 2014; Lea et al., 2003; Lodish et al., 2008; Nelson and Cox, 2014).

The oxidation (meaning the “burning”) of nutrients’ components is the main sources of electrons and protons, coming from glycolysis (carbohydrates catabolism), Krebs cycle, beta-oxidation of fatty acids (lipid catabolism), and also the oxidation of amino acids (amino acids, peptide, and protein catabolism). These oxidation processes transfers the electrons and protons to different coenzymes, like NAD (nicotinamide adenine dinucleotide), FAD (flavin adenine dinucleotide) – which can appear in reduce (as $NADH + H^+$ or $FADH_2$) or oxidative state (as NAD or FAD), binding to specific proteins of the electron transport chain (ETC) responsible for electrons and protons transfer (figure 3) – that represents the first stage of the ETC.

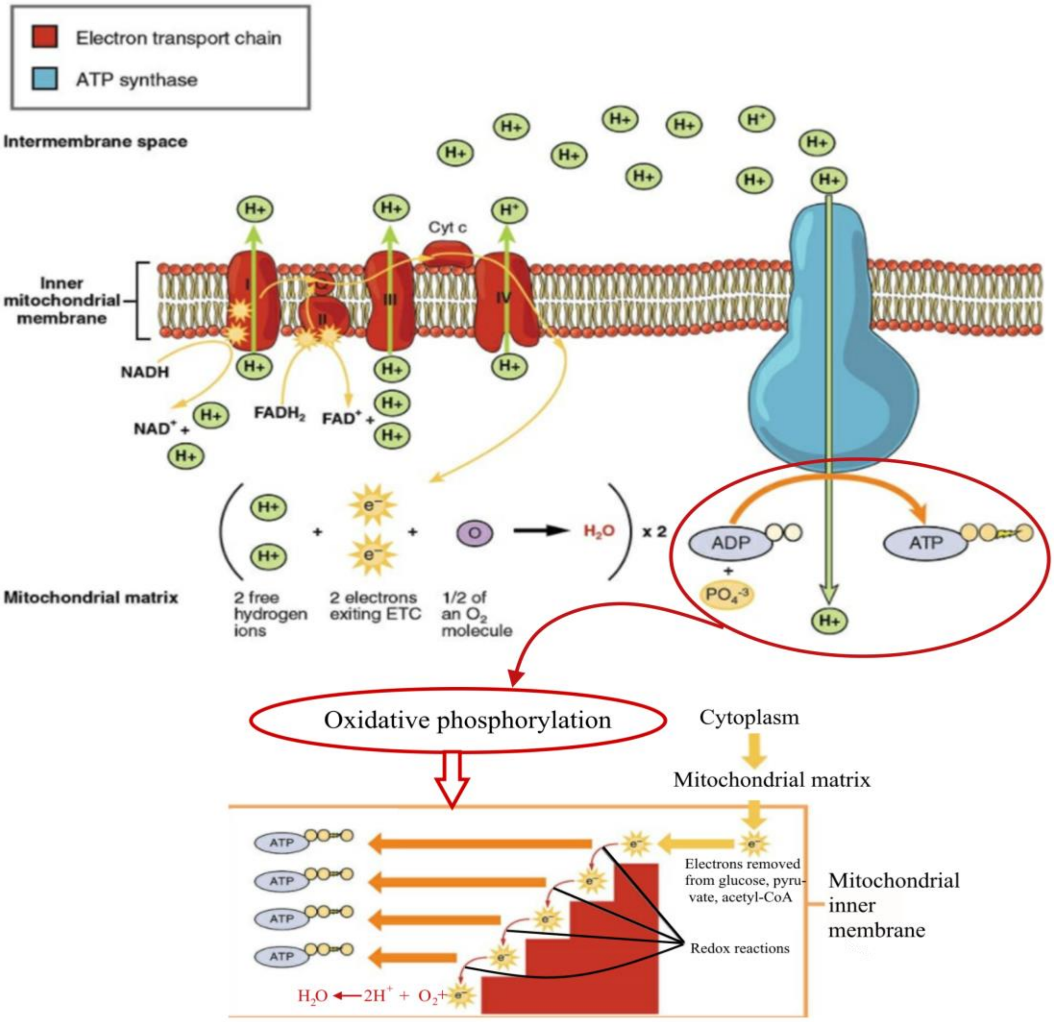

Figure 3. Oxidative phosphorylation and electron transport chain in mitochondria

The electron transport chain involves four specific protein complexes (named as complex I; complex II; complex III; complex IV), which have the duty to receive electrons from specific coenzyme or from the anterior complex from the ETC. Thus, complex I takes the hydrogen and electrons from HADH + H^+ releasing energy that is used to pump and concentrate the H^+ in the inner mitochondrial membrane. Complex II also receive electrons and protons from $FADH_2$ and Krebs cycle, and the energy released is used than for next ETC's stage. Than the electrons are transferred to oxidative CoQ that will become reduced as CoQH2, that transfers the electrons to the cytochrom C and release H^+ from complex III, which transfers and pumps lots of H+ across the membrane towards to the final complex IV, which will passes the electrons to activated oxygen molecules that find and reacts with hydrogens and produces water molecules. After these four protein complexes, there is the oxidative phosphorylation process which closes this very detailed but important process.

The water intake is stimulated by increases in plasma osmolality that stimulates the thirst center from the hypothalamus which leads to the increases in water intake. The excretion of water from the body is done through urine – as the main route, through the skin as a result of perspiration, through the lungs – along with respiration, as well as through feces – as a result of food and feed digestion.

The balance between the water and electrolytes (especially sodium and potassium) intake and excretion may lead to critical conditions, such as edema (excess fluids trapped in different tissues that cause swelling) – when water intake is much higher than excretion, or dehydration – when water intake is much lower than excretion.

CONCLUSIONS

Water is one of the most important molecules from all biochemical components of the cell. By its essential roles in living cells, it is indispensable in all cells and tissues, but the distribution is very different between tissue cells, varying from 10% in the tooth to 85% in the brain.

Optimum hydration makes it possible that the cell's membrane to be able to keep its shape and function. The cell composition could be seriously affected because, in excess of water or dehydration, the cell membrane could be impossible to keep inside the cell important molecules with a critical role.

The water intake stimulates the thirst center from the hypothalamus which leads to increases in water intake, the animal being thirsty. In opposite, the excretion of water is made through urine, skin, lungs, and also through feces. The optimum water and electrolytes balance are mandatory for good health status.

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INVESTIGATION OF SOME FACTORS INFLUENCING THE WATER INTAKE BY DAIRY COWS

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ABSTRACT

Drinking water intake of lactating Hungarian Simmental cows was examined in July 2019. The study period was characterized by mild heat stress, as the mean of THI1 values was 70. The correlation of daily water intake (WI) with dry air temperature (Td), relative humidity (H), wet air temperature (Tw), different temperature-humidity indices (THI1 and THI2), external body temperature (BT) and milk production (MP) were calculated. WI was more closely related to Td ($r = 0.87$), than to Tw ($r = 0.80$) and was not related to H ($r = -0.10$). The correlations between WI-THI1, and WI-THI2 were strong ($r = 0.84$ and 0.88). WI was less associated with BT ($r = 0.51$), than with weather indicators, but this association was also significant ($p < 0.01$). However, a very strong negative correlation was found between WI and MP ($r = -0.91$); r (WI, MP · THI1) = -0.70; r (WI, MP · Td) = -0.58.

Keywords: dairy cow, drinking water, water intake, heat stress

INTRODUCTION

The water circulation in the body of dairy cows is very intense. The total water demand of a cow producing 35 kg·day^{-1} milk at 28°C can be estimated at 133 litres, of which approx. 115 litres (more than 85%) are covered by drinking water (Schmidt, 2015). The body of the animals contains 50-80% water, which is approx. 430 kg for a 650 kg cow. The 133 litres of water in the previous example is 30% of this amount, which the body must to change daily. Therefore, it is very important to supply dairy animals with the right amount and quality of water.

Since the cow's milk contains 87-88% water, a higher milk production puts a considerable strain also on the water circulation of cows. At the same time, the body loses water through urine and feces, but also during the process of heat-regulation, and the importance of the latter is expected to increase with global warming.

Heat stress occurs when the balance between heat production and heat loss in cows is unhinged, meaning that they are no longer able to compensate for the increase in ambient temperature. These problems affect nowadays not only tropical, subtropical and Mediterranean climates, but are becoming more common during the summer months also under the temperate climate. In the 21th century, higher maximum temperatures, more hot days and heat waves are expected almost everywhere on the mainland (IPCC, 2001 – http1). It has long been known, that the degree of heat stress in cows is affected also by relative humidity, in addition to air temperature (Bianca, 1965). The evaporation in the humid air is less effective for the cows to cool their bodies (West, 2003). This is why many indicators have been introduced, that take into account the air temperature and humidity together (e.g. the temperature-humidity indexes; THI1-6). Of these, THI1 or THI2 is recommended in Hungary.

$$THI1 = (0.15 \times Td + 0.85 \times Tw) \times 1.8 + 32$$
$$THI2 = (0.35 \times Td + 0.65 \times Tw) \times 1.8 + 32$$

In which:

Td = dry air temperature (°C)

Tw = wet air temperature (°C)

The corresponding limit values are 68 (THI1) and 69 (THI2) (Reiczigel et al., 2009; Solymosi et al., 2010).

The daily water intake of cows is also influenced by the amount of dry matter consumed and its chemical composition, such as the nitrogen (crude protein), but even more so the potassium content. The body increases primarily the *total* water intake, and not only the *drinking* water intake, so that it can excrete the excess from these substances (Kume et al., 2010).

Several studies show, that the cattle and buffalo tolerate relatively the high concentrations of macro elements (Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-) in the drinking water. However, beyond a limit, the concentration of solutes already reduces the water consumption of the animals, and thus also the dry matter intake and production (Ribács and Galló, 2018).

The temperature of the drinking water also determines the daily water intake of the cows. During time of heat stress, the sufficiently cold (10°C) drinking water can effectively help reduce body temperature (Wilks et al., 1990), while the animals need to consume more of the higher temperature drinking water, to achieve the same effect (Atrian and Shshryar, 2012). However, in winter, cows prefer the heated (30°C) drinking water (Petersen et al. 2016).

In this study, the effect of some weather parameters, such as the dry air temperature, relative humidity, wet air temperature, THI1 and THI2 values, as well as the external body temperature and milk production on the drinking water intake of dairy cows was investigated.

MATERIALS AND METHODS

The examinations in Hungary (in the Southern Great Plain, Békés County), was conducted between 1 and 31 of July 2019, on 20 Hungarian Simmental cows. All cows included in the study were *multiparous*, 47-170 days had elapsed since their last calving at the start of the study. (The farm has an average lactation length of 260 days.)

The cows received the following daily ration:

- 8 kg corn silage
- 3 kg grass hay
- 3 kg alfalfa hay
- 6.12 kg concentrates

The composition of concentrates:

- 49% corn
- 33% barley
- 16% soybean meal
- 2% feed supplement (with dextrose and calcium carbonate)

This feed ration, based on 650 kg body weight and 4.0% milk fat, theoretically covers the production of 14-15 kg milk. It has a moderate dry matter content (13.3 kg), a high proportion of fodder concentrate (about 50% of the net energy for lactation), but at the same time has an adequate crude fibre content (18% of the dry matter content) well suited to heat stress cows (West, 2003).

The drinking water was between 12 and 14°C, colourless and odourless, with no visible impurities. It was provided *ad libitum*. The cows used an automatic drinker, with a flow meter fitted in the refill line. At 6 pm each day, before the evening milking, was read how much the group had consumed in the last 24 hours. The daily water intake was converted to 1 cow.

Animals were milked twice daily at 7 and 18 hours. The bulk milk was weighed and the daily milk production was converted to 1 cow.

The external body temperature was measured non-contact, with a Medisana TM-750 thermometer, on the anus region, that is, on the body not covered with hair. The measurements were performed individually, once daily at 15 hours, that is at the end of the warmest period.

The dry air temperature (Td) and the relative humidity (H) at the test site were determined simultaneously with a digital measuring instrument. These measurements also were performed once daily at 15 hours. The wet air temperature (Tw) to calculate the THI1 and THI2 values was calculated from the measured data using a h-x calculator (online; http3).

Statistical data processing was performed in Microsoft Excel 2016. The correlation between the parameters was investigated by calculation using the following formula:

$$r = \sum(x-\bar{x})\times(y-\bar{y}) / \sqrt{[\sum(x-\bar{x})^2\times\sum(y-\bar{y})^2]}$$

In which:
$\bar{x}$ and $\bar{y}$ = the average value of the data arrays

RESULTS AND DISCUSSION

Meteorological characterization of the examined period

The (dry) air temperatures measured at 15 hours ranged from 22.9 to 33.5°C, while the relative humidity ranged from 31 to 64%. From the recorded data, the temperature-humidity indices (THI1) of 63-81 can be determined. The mean of the THI1 values was 70 ± 4, so the month as a whole can be characterized by a mild heat stress. 12 days (38.7% of the study period) was not heat stressed (THI1 ≤ 68). 17 days (54.8%) was mild heat stressed (THI1 = 69-78), while a medium-strong heat stress (THI1 = 79-88) was recorded for 2 days (6.5%; occurred only on the first and last day of the study period).

Relationships between drinking water intake and meteorological parameters

The water consumption of cows varied between 74.7 and 101.9 l/cow/day, during the study period. The exact value was correlated primarily to the *dry* temperature of the air ($r = 0.87$; $p \leq 0.001$) *(Figure 1.)*, and not to the *wet* temperature ($r = 0.80$; $p \leq 0.001$) *(Figure 2.)*, although both correlations are strong. The wet temperature of the air is highly dependent on the relative humidity. Bianca's (1965) studies confirmed that the heat stress could be different at the same temperature but with different humidity, as the milk production of cows was very different. In our experience, however, the daily drinking water intake was more strongly affected by the *dry* air temperature. In dry air, the mucous membranes of the mouth dry out sooner.

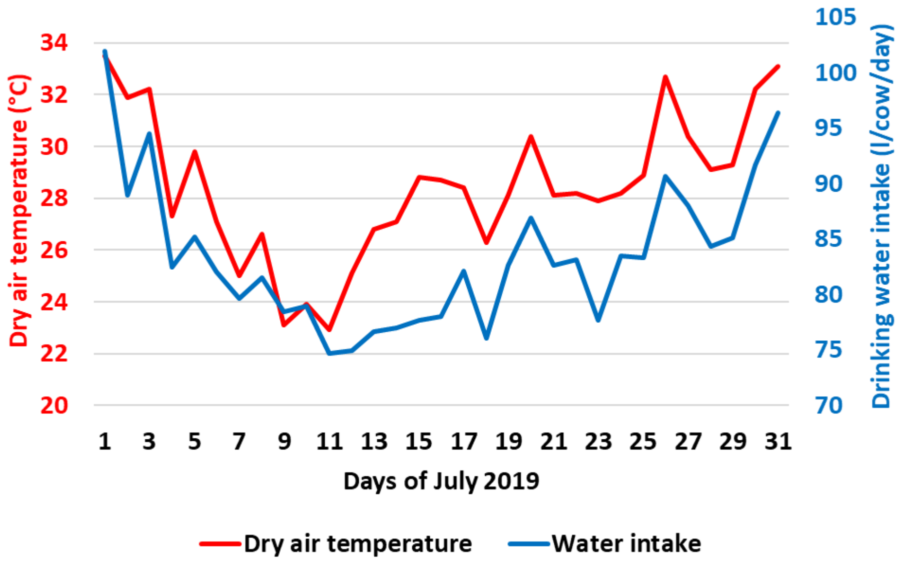

Figure 1. Relationships between the water intake and *dry air temperature*

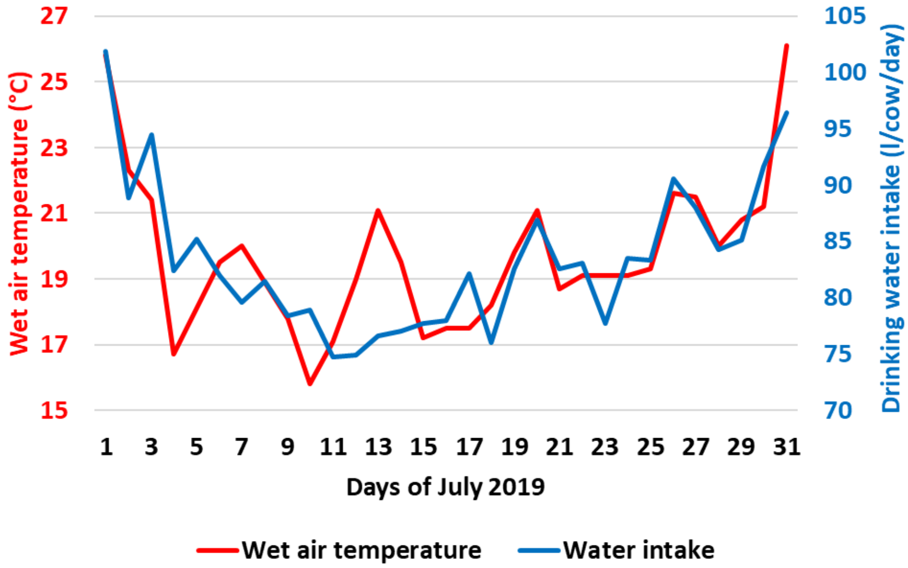

Figure 2. Relationships between the water intake and *wet air temperature*

Ignoring the air temperature, no direct relationship between relative humidity and water consumption could be detected ($r = -0.10$; $p > 0.1$) *(Figure 3.).* However, the daily water intake was closely related to temperature-humidity indices, which take into account *both the dry and wet* temperatures of the air. The correlation was $r = 0.84$ ($p \leq 0.001$) for THI1 *(Figure 4.)*, and $r = 0.88$ ($p \leq 0.001$) for THI2 *(Figure 5.).*

At high temperatures, the animals consume significantly more drinking water than the minimal requirement of intermediate metabolism and the evaporation. Blaxter et al. (1959) observed this for sheep, while Richards (1985) and Silanikove (1989) observed this for dairy cows. As a defense, the animals increase the total water content of their bodies, thus practically increasing the *specific heat* their bodies. Because of this, they be able to temporarily storage of the excess heat, which can be more easily released during a cooler period (at night) (Schmidt-Nelsen, 1964).

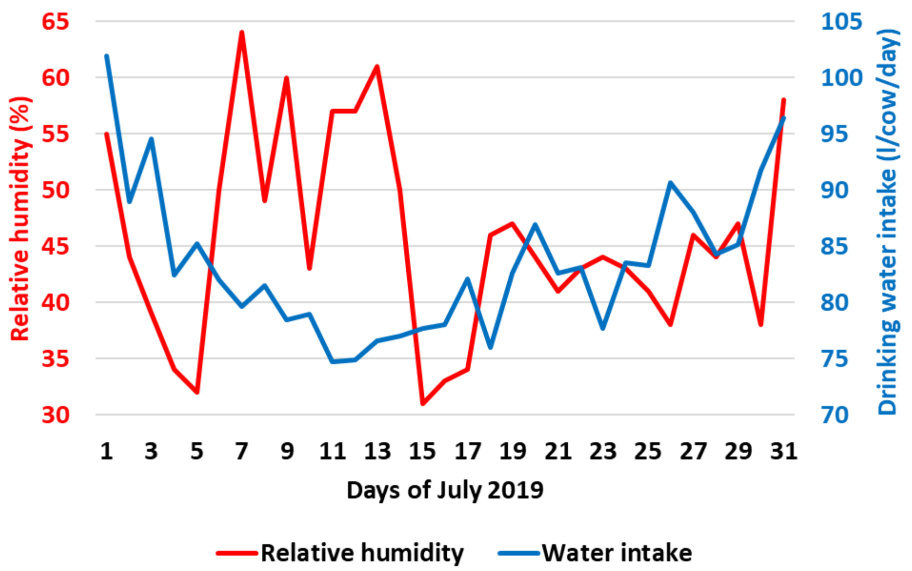

Figure 3. Relationships between the water intake and *relative humidity* of air

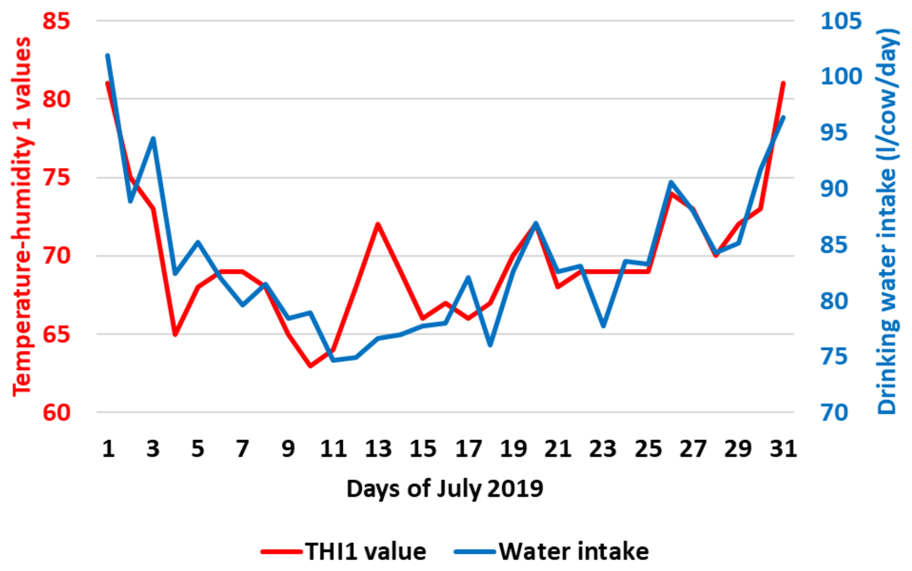

Figure 4. Relationships between the water intake and *THI1 values*

Relationships between drinking water intake and body temperature

The external body temperature of the cows measured at 15 hours was always within the physiological limits, ranged from 38.1 to 39.1°C. The average of the group on heat stress days was almost half a degree (0.4°C) higher, than on non-heat stress days ($p \leq 0.002$) (Komlósi and Ribács, 2020). There is a moderate correlation between daily drinking water consumption and external body temperature ($r = 0.51$; $p \leq 0.01$) *(Figure 6).* That is, the relationship is not as strong as for the air temperatures (Td, Tw, THI1, and THI2).

In the case of heat stress, the balance between heat production and heat loss in cows is unhinged; therefore, their rectal temperature of the cows can rise by as much as 0.5°C (Bouraqui et al., 2002).

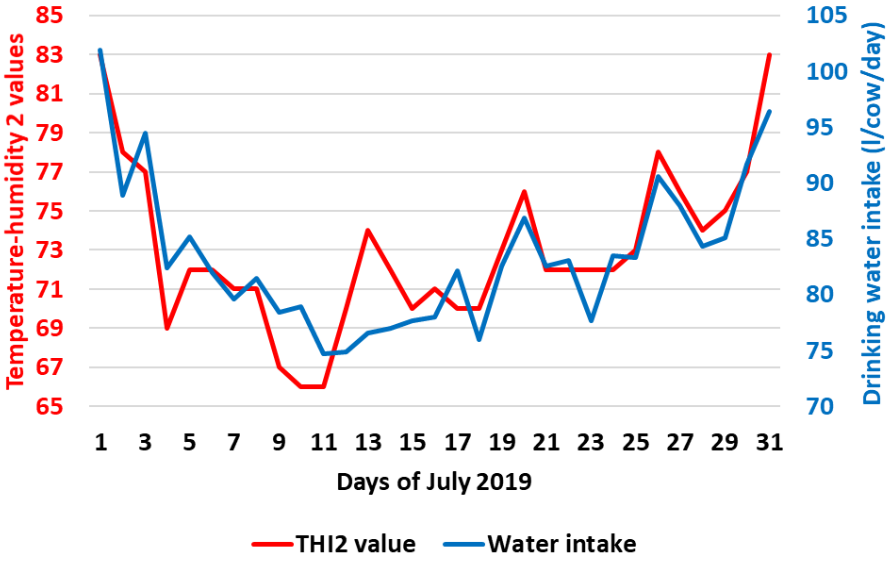

Figure 5. Relationships between the water intake and *THI2 values*

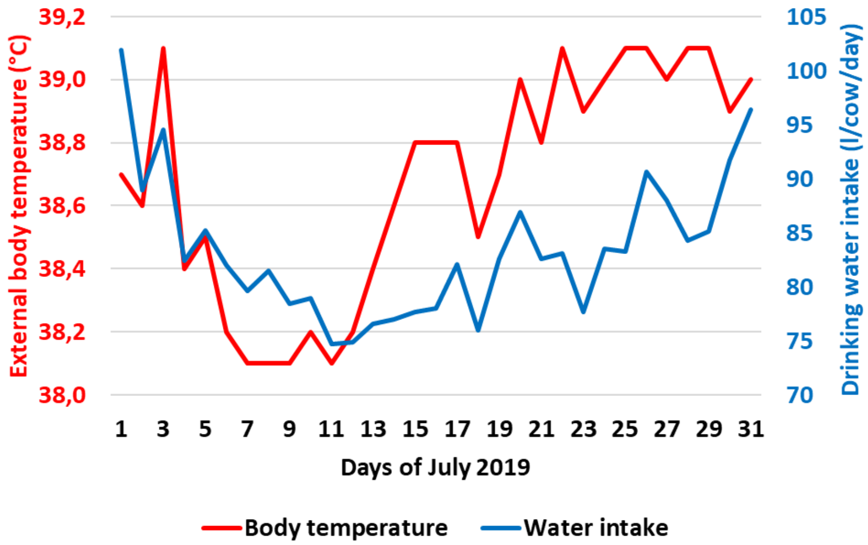

Figure 6. Relationships between the water intake and *external body temperature*

Relationships between drinking water intake and milk production

The milk production of the cows varied between 8.3 and 14.2, on average 12.2 ± 1.7 l/cow/day. An extremely strong *negative* correlation was found between the daily drinking water intake and milk production ($r = -0.91$; $p \leq 0.001$) *(Figure 7.)*. The dairy cows consumed the most water on the days when their milk production was lowest. This can be caused by the fact that both drinking water intake (WI) and milk production (MP) are related to the weather, more specifically to the heat stress. The degree of heat stress is usually determined by the temperature-humidity index (THI1).

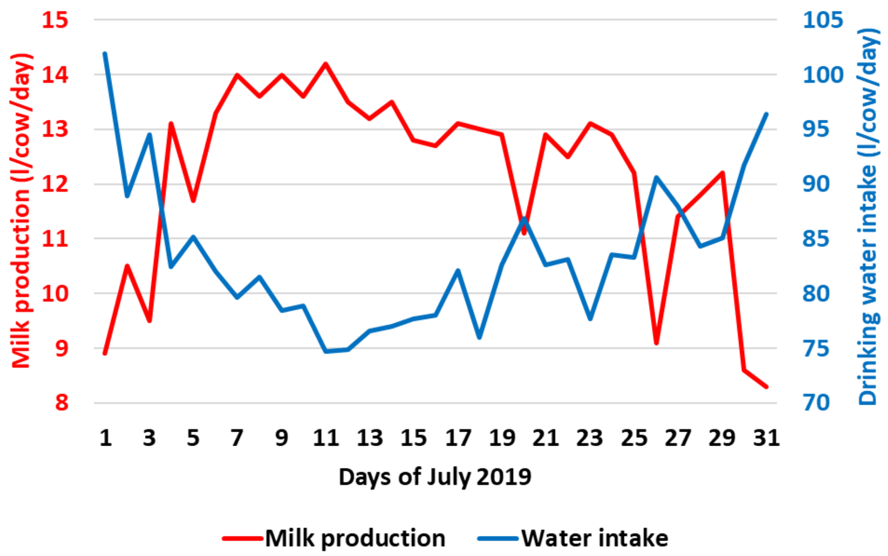

Figure 7. Relationships between the water intake and *milk production*

If the THI1 values are fixed, the partial correlation between water consumption and milk production weakens: r (WI, MP · THI1) = -0.70, but remains significant ($p \leq 0.001$). Further weakening can be observed, if the dry air temperature (Td) values are fixed, instead of THI1: r (WI, MP · Td) = -0.58 and $p \leq 0.001$. The negative correlation is maintained at a medium level in this case as well. It would be worthwhile to examine this phenomenon in high-performance dairy breed as well.

Assuming a uniform water content of 87%, the water excreted into the milk was 7.5–16.5% of the daily drinking water intake. This rate depended particularly on the *dry* air temperature (r = -0.93), less on the *wet* air temperature (r = -0.79), and least on the external body temperature (r = -0.61), but the correlation is significant in all the three cases ($p \leq 0.001$).

The body weight of the cows was not measured in this study, but Richards (1985) experienced an increase in body weight during the period of heat stress. This seemingly contradicts the fact that the feed intake of cows usually decreases due to heat stress (Polsky and Keyserlingk, 2017). However, this confirms Schmidt-Nelsen's (1964) theory, that the heat-stressed cows create a reserve of water to increase the specific heat of their bodies. In addition to increased evaporation, this process can also cause a decrease in the rate under study.

In the case of heat stress, the decrease in milk production is a complex process, i.e. it can be caused by several facts. The changed water circulation alone does not explain this. According to Polsky and Keyserlingk (2017), the decline in milk production is primarily due to less energy and protein intake. Furthermore, the balance of endocrine system is disturbed, as a result the level of prolactin in the blood changes. Pragna et al. (2017) studied the effect of prolactin levels on the milk production.

The effect of heat stress on the cattle also depends on the breed and the level of production. The dairy cows are more sensitive to heat stress than beef cattle. Within a given breed, the high-performance cows are less able to withstand heat stress because their own heat production is significantly higher than that of low-performance cows or the dry cows (Spiers et al., 2004; Bernabucci et al., 2010; Ríos-Utrera et al., 2013).

CONCLUSIONS

In the herd and conditions studied, the intake of drinking water was highly dependent on meteorological factors, especially on dry air temperature. There is also a strong correlation with the wet air temperature and with the two types of temperature-humidity index (THI1 and THI2), but there is no direct correlation with the relative humidity of the air.

The water consumption was less related to (external) body temperature than to ambient temperature. However, it should be noted that the body temperature of the cows was normal during the whole study period. In contrast, the dry air temperature exceeded 25°C on 27 days (87.1%), and 19 days (61.3%) was heat stressed for based on THI1 values.

The ratio of water excreted into milk to drinking water intake decreased sharply with increasing temperature. This ratio was mostly determined by the dry air temperature.

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http3: http://www.bausoft.hu/php/hx/hxCalc.php Download: 01.07.2019.

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