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SECTION 01
ENVIRONMENTAL SCIENCE
AND ENGINEERING

REVIEW ON AQUAPONIC SYSTEMS AND THEIR POTENTIAL IN THE REALM OF SUSTAINABLE AGRICULTURAL PRACTICES

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Abstract

This article is an overview of the agricultural practice by the name of “aquaponics”, which merges aquaculture and hydroponics (growing vegetables in a soilless environment) in a completely controlled environment in order to ensure sustainable food production, thus eliminating the obstacles induced by meteorological conditions, scarce resources, lack of farmland, and other external factors threatening large-scale food security. This paper will present the working principle of this relatively new farming practice and provide a look at the advantages and disadvantages of using aquatics for agricultural production. With a better understanding of this technology and its true potential, all the while taking into account the minimisation of any associated environmental impact, it has been found that aquaponic systems constitute one of the ways of the future in terms of sustainable farming practices.

Key words: aquaculture, aquaponics, hydroponics, sustainability.

INTRODUCTION

Aquaponics is an agricultural practice that combines aquaculture (fish farming) and hydroponics (growing plants without soil). It is a form of sustainable agriculture that uses a closed-loop water recirculation system (Figure 1) to produce food from a combination of fish, vegetables, and micro-organisms [1]. In recent years, it has gained ground as a viable alternative to traditional agriculture because of its potential to reduce environmental impact while ensuring food security [2]. Aquaponics systems can produce both fish and vegetables without the need for large areas of land or large inputs of water, fertilisers, and pesticides. This makes them ideal for urban environments where space is limited, and resources are scarce.

Aquaponic systems have many advantages over conventional farming methods, such as reduced water use, increased efficiency in nutrient cycling, reduced use of hazardous chemicals, improved soil quality and preservation of biodiversity. In addition, they can be used to produce higher yields with less effort than other

types of agriculture, as they require fewer labour hours per unit area compared to traditional farming practices [3].

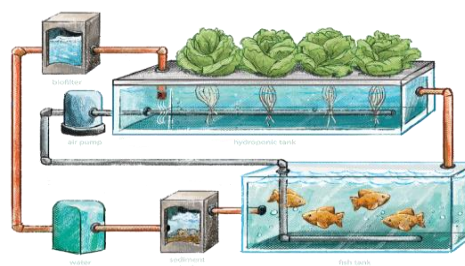


Figure 1. Diagram of an Aquaponic System

However, despite these benefits, there are still some challenges associated with this technology that need to be addressed if it is to be widely adopted by farmers around the world.

MATERIALS AND METHODS

An aquaponic system combines aquaculture and hydroponics thus creating an efficient form of food production. Aquaculture is a type of farming that involves raising fish and other aquatic animals in ponds or enclosed plants

without soil, instead using various nutrient solutions that the plants require. Those nutrients are absorbed by the plant roots, which are submerged in water. The plants grow on floating rafts or other physical support systems that also ideally deprive the water of sunlight to prevent algae from forming therein.

Aquaponics therefore involves using aquatic animals such as fish, shrimp, crayfish, or frogs together with plants grown in water without soil. This symbiotic relationship between the two elements allows for an efficient nutrient cycle that can take place without the use of chemical fertilizers or pesticides [4].

The fish are housed in a special aquarium called a grow-out aquarium, where they produce waste that is then converted by nitrifying bacteria into nutrients that can be used by plants growing in a connected hydroponic system. Water from the fish tank is then circulated through the hydroponic system and filtered before returning to the tank. This process provides an organic source of nutrients for the plants and at the same time cleans the water for the aquatic life that lives in the grow-out tanks.

Nutrient cycling is an essential part of the aquaponic system as it allows efficient use of resources such as fish waste and nutrients for plant growth. Nutrients in an aquaponic system are circulated in a two-step process. The bacteria

involved in this process are mainly composed of two types: nitrifying bacteria and denitrifying bacteria.

The first step is the conversion of fish waste by bacteria into nitrates, which are then used as nutrients for plants grown in the same medium (water). Nitrifying bacteria, such as *Nitrosomonas* and *Nitrospira*, convert ammonia from fish waste into nitrites and then eventually into nitrates that are easily absorbed by plants. These types of bacteria need oxygen to carry out their metabolic processes, making them strictly aerobic (oxygen-dependent) organisms.

The second stage involves denitrification, in which denitrifying bacteria convert nitrates back into nitrogen gas or other forms that can be released into the atmosphere. Denitrifying bacteria, the *Paracoccus* species being a prime example, are strictly anaerobic (oxygen-independent) organisms that rely on alternative energy sources, rather than oxygen, to convert nutrients back into forms useful for plant growth, as well as to transport them away from the root zone when concentrations become too high [4].

The water that has been filtered by these bacteria re-enters the fish tank and thus, a nutrient cycle is completed. The aquarium usually has a conical base, allowing the fish waste to settle and to be easily discharged at certain intervals.

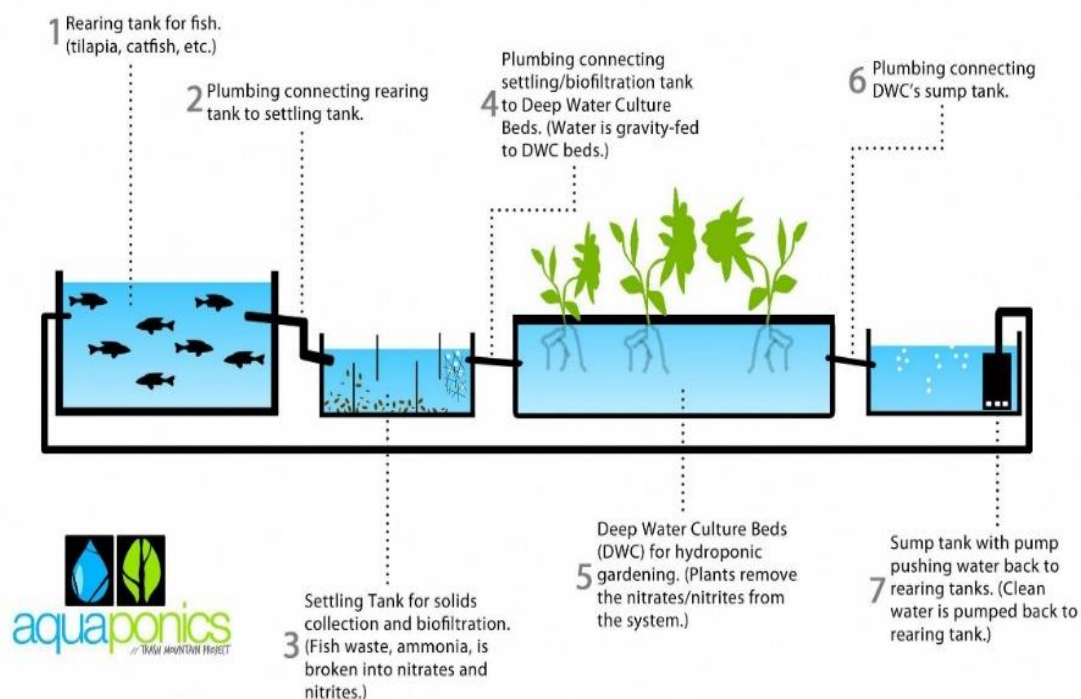


Figure 2. Deep Water Culture Aquaponic System, working principle

For this process to function properly, several key parameters need to be closely monitored and properly managed. These include, among others, pH levels, oxygenation levels, temperature, and stocking density. The ideal pH range for aquaponics is between 6-7 [5], which helps to ensure optimal growing conditions for both fish and plants. In addition, oxygenation levels should also remain within specific ranges, depending on the species grown in each individual system, as this will allow them to thrive while providing enough oxygen to support plant growth. The temperature should also remain consistently warm enough, but not too warm, as this could lead to serious health problems for both aquatic life and plants. The temperature intervals vary depending on the species of aquatic life and plants that have been chosen in a specific aquaponic system.

Aquatic stocking density is another key factor to consider when setting up an aquatic system, as overcrowding can lead to competition between fish, further leading to decreased fish growth rates, and poor water quality due to increased waste from overcrowding. Low-quality water can cause stress (toxicity) on both biological systems, which can lead to poor performance or even death if not managed correctly [6]. It is therefore important to strictly maintain the number of fish required for optimal production, while ensuring that dissolved oxygen levels in the water remain sufficiently high throughout the process cycle so as not to compromise the ability of both organism types to perform their respective roles effectively in their respective environments.

There are several types of plant growing beds:

- Deep Water Culture Beds

Deep Water Culture beds (Figure 3) are flat-bottomed channel-containers, with water that runs 30cm deep, covered with floating rafts made of styrofoam or similar materials. The plants are supported by a cubic structure made of coconut coir or a similar material, which is then placed in same-size holes drilled in the floating rafts. Therefore, the roots of the plants are immersed in water, while the rest of the plant sits on top of the raft, having access to sunlight and proper aeration. The raft itself provides stability for the plants, reducing the risk of tipping or falling over, and the water film allows

efficient water flow, ensuring that the plants receive the nutrients and oxygen they need [7].



Figure 3. Floating rafts on a Deep Water Culture system

Leafy greens such as lettuce, cabbage, and spinach, as well as herbs such as basil and parsley, are ideal crops for the DWC system.

- Grow Media Beds

These are culture beds containing a culture medium (Figure 4 and Figure 5), such as clay or coconut pebbles, which represent the biological filtering surface (conversion of ammonia to nitrate) of the water by the bacteria. Water from the aquarium is pumped into the growth medium, and the plants absorb nutrients as the water filters through the growth medium. This type of grow bed gives better control over the growth medium, as the growth medium can be adjusted to give the plants optimal conditions. In addition, media beds offer the ability to adjust water flow, pH and nutrient levels [7].

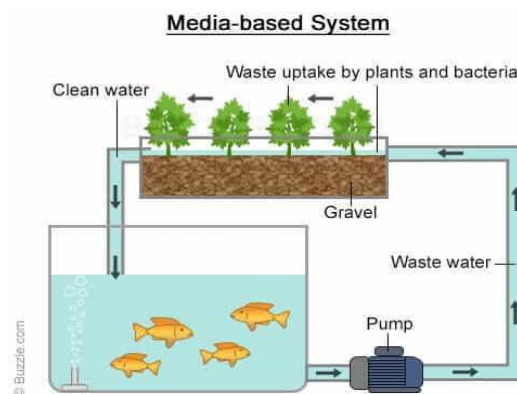


Figure 4. Grow Media Aquaponic System, working principle

A wide variety of crops can be grown in growing medium beds, including tomatoes, peppers,

cucumbers, zucchini and root vegetables such as carrots and beets.



Figure 5. Grow media small scale aquaponic system

- Nutritional Film Technique (NFT)

Nutrient film technique (NFT) channels are narrow channels through which a thin film of water constantly flows, supplying nutrients to plant roots. The plants are suspended above the water and their roots are in direct contact with the water. NFT canals (Figure 6) are very efficient because the flow of water is carefully and more easily controlled than in DWC systems (Figure 7) to ensure that plants receive the exact amount of nutrients and oxygen they need [7].



Figure 6. Nutrient Film Technique commercial aquaponic system

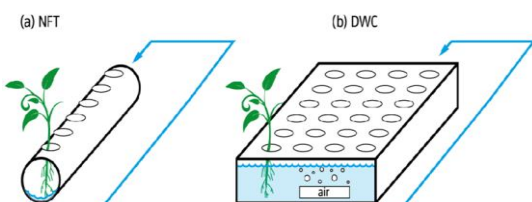


Figure 7. Comparison between NFT and DWC channels regarding water flow

NFT channels are best suited for small, fast-growing crops that don't need much support, such as strawberries, lettuce, herbs, and microgreens.

- Vertical Grow Beds

Vertical culture beds (Figure 8) are large tubes with holes designed to grow plants vertically, either by layering layers of culture beds or by using a porous material attached to the inside of the walls [7]. They are often used in compact aquaponic setups because they allow more plants to be grown in a smaller space. Vertical orientation also gives plants better access to light, which is essential for optimal growth.



Figure 8. Vertical Grow Beds

Spinach, herbs and small fruit crops such as strawberries are ideal crops for vertical growing beds because they do not require much space for roots.

RESULTS AND DISCUSSIONS

Regarding the aquaculture part of the system, it has been found, through trial and error, that certain types of fish offer specific advantages over others and should be selected accordingly. For commercial aquaculture systems, tilapia is considered the best choice due to its fast growth rate, high tolerance to overcrowding conditions and large size, making them ideal for harvesting. Other popular species include barramundi, perch, catfish and carp. All of these species are hardy fish that can tolerate a wide range of pH levels, making them ideal for aquatic systems as they allow greater control over water chemistry, which helps promote healthy plant growth. However, for recreational smaller systems (hobby-scale), more exotic species such as koi and goldfish are sometimes preferred as they offer more colour options to choose from. In addition, these smaller ornamental species tend

to produce less waste than larger commercial-sized species, allowing users with smaller systems to maintain reasonable stocking levels without having to worry about excessive nutrient levels or water quality, minimizing the stringency of monitoring required.

When selecting any type of fish for an aquaponic system, it is important to remember that all types have their own individual needs, so it is important to research each species in detail before introducing them into your system so as not to cause suffering to the living or water quality problems that could lead to poor health or death among plants and fish [8].

In addition, it is also important to note that the more sensitive cold-water fish species should only be kept in regions where temperature fluctuations remain constant throughout the year, as otherwise they are at risk of disease due to sudden changes in temperature, with climate thus playing an important role in fish choice.

Regarding the plant-growing part of the system, the most common type of plants grown in aquaponic systems are robust leafy plants such as lettuce, spinach, Brussels sprouts, rocket, garden cabbage and red beetroot. These crops grow well in the conditions provided by an aquaponic environment and can withstand temperature fluctuations. Other vegetables that do well in aquaponics include broccoli, cauliflower, cabbage, celery, peppers and tomatoes. Herbs such as basil and dill also have a high output in this type of system.

Fruit crops such as strawberries can be grown in an aquaponic system, as long as they are planted with the understanding that there will be a longer harvest time due to the cooler temperatures typically found in these systems compared to outdoor production facilities. Other fruits such as blueberries, grapes and pomegranates can also be grown, but need additional support structures such as trellises or grids to provide support for their delicate branches.

Root crops, such as potatoes and carrots, can also be grown successfully in an aquaponic system, although they require higher amounts of nutrients than other types of plants because of their higher metabolic requirements. The same is true for legumes such as peas or beans, which often require additional support structures such

as trellises or arches to ensure adequate structural integrity.

In addition to vegetables and fruit, ornamental plants such as water lilies and mosses can be grown, which not only provide aesthetic benefits, but can help filter impurities from the water in the system and at the same time increase oxygenation levels. Many people even grow edible flowers, such as chickpeas, which provide both beauty and flavor when used as a garnish on salads or other dishes [9].

In general, it is important to note that not all types of plants will grow equally well in an aquaponic system, so conducting a detailed survey of each species prior to planting is recommended for maximized success rates along with improved yields over traditional farming methods. In addition, investing in appropriate support structures when necessary should help ensure healthier crop growth while limiting potential losses due to unfavorable environmental conditions for plant development.

- Advantages of aquaponic systems

Compared to traditional agriculture, aquaponic systems require far fewer resources for the same production yield and have many benefits which will be detailed below.

For a start, aquaponics offers great versatility due to the controlled environment in which it is carried out. Unlike traditional farming methods, aquaponics systems allow complete control over humidity and heat levels in the greenhouse, ensuring optimal growing conditions for plants and fish throughout the year. This means that vegetable production can take place in any climate or region - making it a viable option for those living in areas with extreme or highly changeable weather patterns, where outdoor growing is not possible or is severely limited by the seasons.

Also because of the controlled environment in which it sits, the aquaponic system is also less prone to pests and other common agricultural threats because there are no outdoor soil beds or other exposed areas for insects or animals to enter. By creating a water-based system instead, only bacteria and micro-organisms used as part of the natural nitrogen cycle will be present - helping to reduce the risk of contamination from

outside sources, while reducing the need for costly chemical fertilizers and pesticides.

In addition, by eliminating the need for tillage, aquaponic systems take up much less space than conventional cultivation methods, while still producing high yields per unit area due to the faster growth rate associated with this type of cultivation. With careful planning and design, multiple aquaria and culture beds can even be linked together into larger networks capable of producing enough food for entire communities - something that would otherwise be impossible with traditional farming techniques.

Given the fact that the aquaponic system is a closed circuit and recirculating, water can be reused several times without the need for frequent replacements or refills. In addition, due to the absence of soil in an aquaponic system, less water is lost that would have been lost through soil absorption and evaporation, saving up to 90% of total water consumption compared to traditional cultivation methods [11]. In addition, since there is no need for soil loosening, compaction due to machine traffic is drastically reduced, leading to higher levels of bioactivity in the root zone, which helps reduce nutrient leaching into nearby water bodies and other areas where it could be harmful due to excessive concentrations accumulating over time [10].

In parallel to water savings, aquaponics also allows significant energy savings compared to traditional agriculture. Due to its small size and increased efficiency, aquaponics systems require much less energy than traditional farming techniques, leading to energy savings of between 10 and 20%, according to The International Journal of Agricultural Research (IJAR) [12]. These savings come from various factors, such as reducing the need for chemical fertilization, pest control treatments and irrigation equipment, all of which consume large amounts of electricity and fuel when used in conventional farming practices.

Finally, aquaponics systems reduce reliance on expensive chemical fertilizers, which not only reduces the costs associated with production, but also eliminates most of the environmental impacts associated with typical farming practices, such as synthetic runoff and over-fertilization. Fish waste provides a high level of readily available nitrogen, phosphorus and other

essential minerals that can be taken up directly by plants growing in an aquaponic system, rather than having to be pre-processed with fertilizer before application. This not only provides a sustainable source of nutrients for plant growth, but also makes it easier for farmers using this method, as they don't have to worry about purchasing additional chemicals or treatments needed for their crops to thrive. In turn, this increases the quality of production, resulting in fruit and vegetables with far less harmful effects on the human body compared to produce from pesticide-dependent crops.

- Disadvantages of aquaponic systems

Despite their many benefits, there are also some risks associated with aquaponic systems when implemented widely or in certain environments. For example, if not managed properly, these systems can create an increased demand for energy sources such as electricity or fuel, which could have a negative impact on could disrupt natural habitats and species diversity if not handled responsibly [13].

Also, in terms of waste resulting from the production process in an aquaponic system, this includes solid organic waste from fish, wastewater that needs to be replaced after a certain number of circulation cycles in the system, plastic plates in which plants grow that need to be replaced due to potential damage, and consumable parts of water filters and oxygen pumps, and water pumps. Of course, if organic waste is composted, wastewater is transferred to a treatment plant, and recyclable materials are recycled and reclaimed, the aquaponic system is much more environmentally friendly than traditional farming practices, which affect the environment in a much more direct way, polluting both soil, air and waterways through the pesticides and synthetics used and the greenhouse gas emissions from large agricultural machinery, for example.

Although it has no direct environmental impact, one of the biggest drawbacks of an aquaponic system is the time, effort and money required to set it up. Unlike traditional farming methods, where land can easily be purchased and sowing seeds is enough to start growing crops, setting up an aquaponic system requires careful planning and detailed analysis to ensure its long-term success. Firstly, the appropriate components for the functional loop must be

selected and purchased. This usually includes items such as an aquarium, plant culture bed, filtration unit, air pump, water heater, hydroponic nutrients (for nutrient supplementation, if applicable), fish feed and other necessary supplies, making this form of food production an expensive affair. Secondly, once all the components have been purchased, they must then be properly installed to ensure optimal performance. Depending on the complexity of the system, this may require a significant amount of knowledge in plumbing and electrical installation techniques [13].

Finally, an equally important step and potential hurdle is the monitoring and maintenance of the aquaponic system. This includes regular testing of pH levels as well as nutrient concentrations in the water - both of which must remain within accepted ranges for optimal growing conditions for both plants and fish. In addition, any mechanical or electrical component needs regular overhauls or repairs in case something breaks down due to wear and tear from constant use [14]. Thus, setting up an aquaponic system involves a significant amount of time, effort, and resources. However, with careful planning combined with a little determination, anyone can succeed in growing their own fresh produce.

CONCLUSIONS

Aquaponics is a sustainable and beneficial farming practice that offers numerous advantages over traditional farming practices. It uses up to 90% less water while producing high quality crops. It has the potential to produce enough food for entire communities due to its versatility in any climate or region and eliminates the need to till the land, which reduces the environmental impact associated with conventional farming methods. Also, with careful management and monitoring, there is little risk of spreading disease or pests among fish and plants - making it one of the safest ways to grow produce. By eliminating the use of pesticides, agricultural production is healthy, organic and has no harmful effects on the human body.

Although traditional agriculture still plays an important role in feeding our population today, it cannot compete with aquaponics when it comes to resource conservation and

sustainability. By taking advantage of natural processes such as microbial activity and nutrient cycling in a closed-loop design system, aquaponic systems offer significant reductions in both operational costs and environmental impact, while providing equivalent or even higher production yields than traditional farming techniques.

Despite a few drawbacks, aquaponics systems are a viable alternative to traditional agriculture, given their greater efficiency when properly managed and maintained.

It should be noted that it is a technique in continuous development, with future optimisation and automation potentially making it the most cost-effective method of agricultural production available to mankind.

In conclusion, aquaponics is a state-of-the-art new technology that offers an efficient and sustainable alternative to traditional agriculture. It is, in short, the way of the future in terms of sustainable farming practices.

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FILAMENTOUS FUNGI AS PRODUCERS OF NATURAL PIGMENTS

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Abstract

The filamentous fungi are among the most dominant phylum in the nature and great due to their significant contributions to biotechnological applications for the welfare of human being. Filamentous fungi are widely distributed in diverse ecological niches and produce extraordinary range of secondary metabolites. The pigments from filamentous fungi were used as food colorants, natural dyes in textile industry, cosmetics and pharmaceutical industry. Natural pigments from filamentous fungi serve as a green alternative to synthetic dyes in food colorants, cosmetics and are biodegradable in nature.

Filamentous ascomycetes fungi are known to produce an extraordinary range of colours. There is a wide selection of non-pathogenic strains of filamentous fungi that are non-toxin producers and can be used as potential sources of natural food colorants with improved functionality. The ability of these fungi to grow on residuals of different complexity (e.g., starch-based, lignocellulose-based residuals) is well-documented, showing versatility regarding different processes that can be built around the filamentous fungi. Unlike the use of pigments from vegetables and fruits, the cultivation of ascomycetes does not compete with agricultural land for food production, and therefore, the synthesis of pigments is faster due to time-efficient and simple fermentation processes. The fermentation processes generate high yields of biomass together with value-added products such as pigments, organic acids and alcohols. Interest in food-grade pigments is because of the pigments' ability to enhance the products' natural color in order to indicate freshness, appearance, safety, and sometimes even to add a novel sensory aspect to attract consumers.

A few strains of ascomycetes filamentous fungi being considered as potential pigment producers include, some strains of Talaromyces (e.g., T. purpurogenus and T. atrovirens producing red pigments), Cordyceps unilateralis (deep blood red pigment), Herpotrichia rhodosticta (orange), Curvularia lunata and several species of Drechslera (many different pigments). Strains of these species are promising because they are non-mycotoxigenic and non-pathogenic to humans. Nevertheless, the individual mycotoxin profiles of these strains remain to be explored. Some other pigment producing fungi for their use in the production of potential food colorants are species of Eurotium and Fusarium oxysporum (yellow and red pigments, respectively), Fusarium fujikuroi (red and orange pigments) and strains of Penicillium such as P. citrinum, P. islandicum, P. aculeatum and P. pinophilum. However, several species of Penicillium are able to produce known toxic metabolites and Eurotium spp. and F. oxysporum have been shown to produce mycotoxins as well. The potential production of mycotoxins is a major problem which limits the commercial application of these strains of fungi. This problem, together with the increasing demand for natural coloring alternatives from both customers and regulators, has triggered investigations and screens for other potential pigment-producing genera of fungi.

In this paper we present the isolation from the environment of some new strains of filamentous fungi on PDA agar culture medium, their cultivation in laboratory conditions for the production of pigments in a liquid medium in a submerged system in incubators with orbital agitation – rotary shaker. We also present the optimization of pigment production on different liquid culture media. The subsequent studies will aim the taxonomic identification of each newly isolated fungal strain, the production of mycotoxins, which could prohibit the use of these fungi as potential producers of useful pigments in the food industry, and last but not least, the isolation and biochemical identification of the molecular structure of pigments produced by these fungi.

Key words: new strains of filamentous fungi, natural pigments, submerged fermentation.

INTRODUCTION

The filamentous fungi are among the most dominant phylum in the nature and great due to their significant contributions to

biotechnological applications for the welfare of human being. Filamentous fungi are widely distributed in diverse ecological niches and produce extraordinary range of secondary metabolites. The pigments from filamentous

fungi were used as food colorants, natural dyes in textile industry, cosmetics and pharmaceutical industry.

Natural pigments from filamentous fungi serve as a green alternative to synthetic dyes in food colorants, cosmetics and are biodegradable in nature.

Filamentous fungi are used in numerous biotechnological applications to obtain fermented foods, enzymes, antibiotics, biological control agents, stimulators for plant growth and development, etc.

Recent studies underline the current interest in the use of filamentous fungi in order to obtain the natural pigments produced by them.

This interest comes as a response to the increased demand of consumers from all over the world for natural products, to replace chemical synthesis products or plant and animal products that are currently used to obtain natural pigments used in the food, textile, leather industry, furniture.

MATERIAL AND METHODS

Petri dishes sterilization

It's made in the oven at 180°C for 1 h (from the moment when the oven reached the temperature we fixed).

Preparation of culture media PDA

- Balance;
- Magnetic stirrer;
- pH-meter;

PDA extract:

- Extract of 200 g potatoes;
- 1 liter water;
- 20 g glucose;
- 1.5 g agar (for solid shape);
- pH 5.6 ± 0.2

Sterilization of culture media

It's made in autoclave for about 15 minutes at 115°C 1.2 atm.

Pouring of solid media culture

At the microbiological hood in Petri dishes.

Taking samples of air

To obtain new strains of fungi filamentous producer of pigments.

Obtaining filamentous fungi

From various biological source (seeds and beans) flaxseed, wheat, chickpea, beans.

Optical microscopy studies

Stereomicroscopic and optical analysis for morphological identification of fungi.

The inoculation

Of selected strains in the screening stage for liquid media culture PDA (at microbiological hood).

The cultivation

It's made in orbital shaker incubator at 150 rpm (rotation per minute) at 28°C for 5 days, followed for another 5 days at the room temperature (22-25°C).

pH determination

Of culture media where the fungi grew for the working parameters optimization which affect the production of pigments.

RESULTS AND DISCUSSIONS

The method for sterilizing laboratory glassware by dry heat in a Memmert oven. Sterilization process – 1 hour at 180 degrees C.



Figure 1. Memmert oven

-Preparation of culture media

-The method for using the Precisa electronic laboratory balance

-The method for using the Heidolph magnetic stirrer hot plate

-The method for determining the pH of culture media with electronic WTW pH meter

PDA medium

extract from 200 g potatoes

1 liter of tap water

20 g glucose

1.5 g agar

pH 5.6 ± 0.2



Figure 2. Laboratory balance and magnetic induction hub

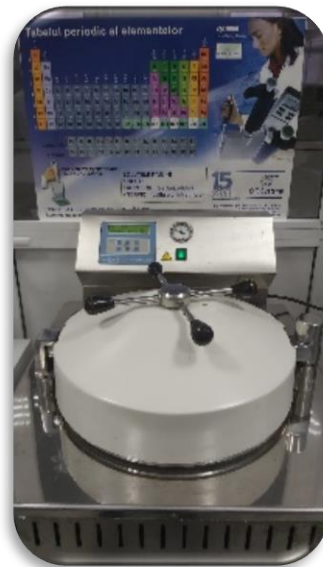
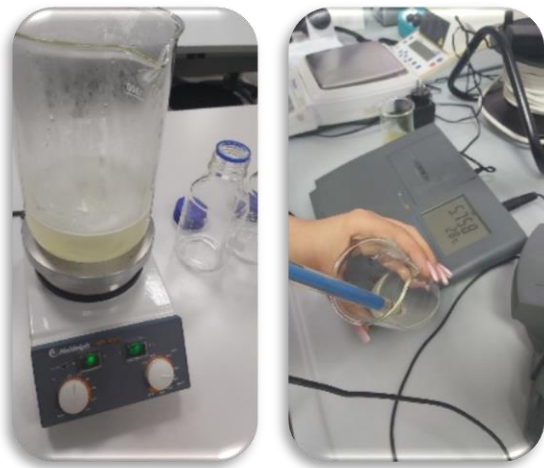


Figure 3. Magnetic stirrer hot plate, bench pH meter

The method for sterilizing culture media by moist heat and pressure in an autoclave – steam sterilizer Raypa.



Figure 4. Sterilization process 15 minutes at 115 degrees C, 1.2 atm

Gravity method for taking air samples – outdoor and indoor



Figure 5. Sampling of outdoor and indoor air samples



Figure 6. Microscopic analysis of the samples



Figure 7. The cultivation



Figure 8. pH determination

CONCLUSIONS

In this paper we present:

- the isolation from the environment of some new strains of filamentous fungi on PDA agar culture medium;
- their cultivation in laboratory conditions for the production of pigments in a liquid medium in a submerged system in incubators with orbital agitation – rotary shaker;
- the optimization of pigment production on different liquid culture media.

The subsequent studies will aim:

- the taxonomic identification of each newly isolated fungal strain;
- the production of mycotoxins, which could prohibit the use of these fungi as potential producers of useful pigments in the food industry, and last but not least,
- the isolation and biochemical identification of the molecular structure of pigments produced by these fungi.

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WATER QUALITY MONITORING FROM THE PRIVATE WELL

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Abstract

Mismanagement of drinking water supplies can pose serious public health risks. There are many concerns about water source management among private well owners, as they are often solely responsible for maintaining their wells, and monitoring and testing of their own water quality. Lack of worry about contamination and a strong sense of control over risks in relation to drinking water quality have been identified as important factors that influence peoples' perceptions and behaviour.

The most effective way to check water supplies for faecal contamination is microbiological analysis, and a range of test methods designed for that purpose has been developed for the water analysis. Instead of carrying out separate tests for each of the potential pathogens, viruses, or parasites that might be in the water, microbiologists test for indicator organisms that are always present when enteric pathogens and viruses are.

Defined substrate technology (DST) developed by IDEXX can produce results in 24 hours. The IDEXX Colilert uses a colourimetric ONPG assay to detect coliforms and a fluorescence MUG assay for E. coli. Colilert can simultaneously detect these bacteria within 18-24 hours. It can also suppress 2 million heterotrophic bacteria per 100 mL present. As of 2014, this technology from IDEXX has been published as a European Standard Method, and many countries now use this technology as their gold standard for water testing like Finland and Ireland. The Enterolert Test from IDEXX uses a proprietary Defined Substrate Technology (DST) nutrient indicator to detect enterococci. This nutrient indicator fluoresces when metabolized by enterococci. DST improves accuracy and avoids the need for hazardous sodium azide suppressants used in traditional media.

In order to achieve the proposed goal, the groundwater sample taken from a family from Tamasi, Corbeanca commune, Ilfov county was analyzed in the laboratory of Ecology and Environmental Microbiology, F.I.F.I.M., U.S.A.M.V. Bucharest from an organoleptic, physicochemical and microbiological point of view.

The groundwater sample from a private well was taken from the kitchen cold tap water of a family in a sterile glass container for organoleptic, physicochemical and microbiological analyses. The underground water from the private well comes from a depth of 120 m and the drilling is located in Tamasi, Corbeanca commune, Ilfov county. The groundwater sample was transported in a refrigerated box to the laboratory of Ecology and Environmental Microbiology within the Faculty of Land Reclamation and Environmental Engineering within the U.S.A.M.V. Bucharest. The experiments performed and presented in this paper represent a part of the studies performed for the bachelor's thesis.

All analyzes for water quality (colour, taste, smell, pH, turbidity, ammonia, nitrites and nitrates) from the private well fall within the maximum limits allowed by the standards in our country, except for the concentration of water hardness that exceeded the limits allowed. Microbiological analyzes for the detection of faecal contamination of the water sample using classic methods and IDEXX defined substrate technology confirmed the absence of coliform indicator bacteria. The recommendation for bringing the water hardness to optimal parameters and falling within the water quality standards was to install a water softening station.

Key words: organoleptic, physicochemical and microbiological analyses, private well, water quality monitoring

INTRODUCTION

Mismanagement of drinking water supplies can pose serious public health risks.

There are many concerns about water source management among private well owners, as they are often solely responsible for maintaining their wells, and monitoring and testing of their own water quality.

Lack of worry about contamination and a strong sense of control over risks in relation to drinking water quality have been identified as important factors that influence peoples' perceptions and behaviour.

The most effective way to check water supplies for faecal contamination is microbiological analysis, and a range of test methods designed for that purpose has been developed for the water analysis.

Instead of carrying out separate tests for each of the potential pathogens, viruses, or parasites that might be in the water, microbiologists test for indicator organisms that are always present when enteric pathogens and viruses are.

MATERIAL AND METHODS

In order to achieve the proposed goal, the groundwater sample taken from a family from Tamasi (Sârbu family), Corbeanca commune, Ilfov county was analyzed in the laboratory of Ecology and Environmental Microbiology, F.I.F.I.M., U.S.A.M.V. Bucharest from an organoleptic, physicochemical and microbiological point of view.

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HI-3824 AMMONIA TEST KIT FOR FRESH WATER

The Hanna HI 3824 chemical test kit is designed to measure concentrations of ammonia in rivers and drinking water reservoirs which indicates the presence of agriculture or urban pollution.

When the concentration of ammonia is high enough, it can alter the smell and taste of water. In industrial applications, high concentrations of ammonia can cause corrosion in pipes.

HI-3874 NITRATE TEST KIT

Nitrate ions are present in trace amounts in surface water and in higher levels in some groundwater. Nitrate is found only in small quantities in domestic wastewater but can reach higher concentration (up to 30 mg/L as nitrogen) in the outflow of nitrifying biological treatment plants.

HI-93708-01 NITRITE HIGH RANGE REAGENT, FERROUS SULPHATE METHOD

The HI-93708-01 are high quality reagents that are pre-measured, allowing for users to achieve fast and accurate colorimetric measurements. These reagents follow an adaptation of the Ferrous Sulphate method in which the reaction between nitrite and the reagent causes a colour change in the sample.

The concentration will be displayed in mg/L (ppm) of nitrite. These reagents are designed to be used with samples that have an expected range of 0 to 150 mg/L nitrite.

HI-38033-100 HARDNESS, TOTAL, EDTA METHOD

Titration is used to find the concentration of an identified chemical in a solution (e.g., water).

Significance and use

Water hardness has traditionally been defined as the capacity of water to precipitate soap.

The ionic species in water causing the precipitation were later found to be primarily calcium and magnesium.

At the present time, water hardness is a quantitative measure of these ions in the water sample.

Now it is also known that certain other ion species, such as iron, zinc and manganese, contribute to the overall hardness of water.

The measure and subsequent control of water hardness is essential to prevent scaling and clogging in water pipes.

1 gpg (grains per gallon) CaCO_3 is equivalent to 17 ppm CaCO_3 (where ppm - parts per million - is equivalent to mg/L).

Chemical Reaction

The hardness level as gpg calcium carbonate (CaCO₃) is determined by an EDTA (ethylenediamine-tetraacetic acid) titration. The solution is first adjusted to a pH of 10 using a buffer solution. The indicator chelates with metal ions such as magnesium or calcium to form a red colored complex. As EDTA is added, metal ions complex with it. After all the free metal ions have been complexed, an excess EDTA removes the metal ions complexed with the indicator to form a blue colored solution. This color change from red to blue is the endpoint of the titration.

IDEXX Colilert-18®

Colilert simultaneously detects total coliforms and E. coli in water. It is based on IDEXX's proprietary Defined Substrate Technology.

When total coliforms metabolize Colilert's DST nutrient-indicator, ONPG, the sample turns yellow.

When E. coli metabolize Colilert's DST nutrient-indicator, MUG, the sample also fluoresces.

Colilert can simultaneously detect these bacteria at 1 cfu/100 mL within 24 hours even with as many as 2 million heterotrophic bacteria per 100 mL present.

E. coli possesses the enzyme β -glucuronidase, which metabolizes MUG, releasing the 4-methyl-umbelliferyl dye.

This dye has the ability to fluoresce under long wave ultra-violet light (365 nm).

After incubating for 18 hours at 35°C, the samples were examined for fluorescence.

IDEXX Enterolert – E

Enterolert-E detects enterococci, such as E. faecium and E. faecalis, in ground water, fresh and marine water.

It is based on IDEXX's proprietary Defined Substrate Technology (DST).

When enterococci utilize their β -glucosidase enzyme to metabolize Enterolert-E's nutrient-indicator, 4-methyl-umbelliferyl β -D-glucoside, the sample fluoresces.

Enterolert-E detects enterococci at 1cfu per 100 mL sample within 24 hours.

RESULTS AND DISCUSSIONS

Organoleptic, physico-chemical indicators for ground water



Figure 1. pH & Turbidity

Table 1. Organoleptic, physico-chemical indicators of the ground water samples
(laboratory environmental conditions - T oC = 28 oC, humidity = 54%)

Indicator name	Test method	Maximum allowable values (see L 458/2002 republished in 2011)	Quantification limit	The determined values
Color	SR ISO 7887/2012	Acceptable to consumers and no abnormal change	-	White - yellowish
Smell	SR EN 1622/2007	Acceptable to consumers and no abnormal change	-	Acceptable to consumers and no abnormal change
Taste	SR EN 1622/2007	Acceptable to consumers and no abnormal change	-	Acceptable to consumers and no abnormal change
pH / Temperature	SR EN ISO 10523/2012	6,5 – 9,5 unit pH/oC	-	sample – 7,2 unit pH/ 28 oC
Turbidity	SR EN ISO 7027/2001	< 5 NTU	-	sample - 0,01 NTU

Classification in German degrees

This divides hard water into 4 categories:
 slightly hard water - it is between 1 and 3.5 degrees;
 moderate hard water - between 3.5 and 7 degrees;
 water with increased hardness - between 7 and 15 degrees;
 very hard water - over 15 degrees.

Classification in parts per million

This is done according to the amount of limestone (CaCO₃, calcium carbonate) present in the water, depending on which there are 5 types of water:
 softened water - the concentration of CaCO₃ is below 17.5 parts per million;
 low hardness water - CaCO₃ between 17.5 and 60 ppm;
 medium hardness water - CaCO₃ between 60 and 120 ppm;
 hard water - CaCO₃ between 120 and 180 ppm;
 very hard water - the concentration of CaCO₃ is greater than 180 ppm.
 One German degree is equivalent to 17.5 ppm.

AMMONIA TEST, NITRITE TEST and NITRATE TEST



Figure 2. Ammonia test, nitrite test and nitrate test

HARDNESS TEST

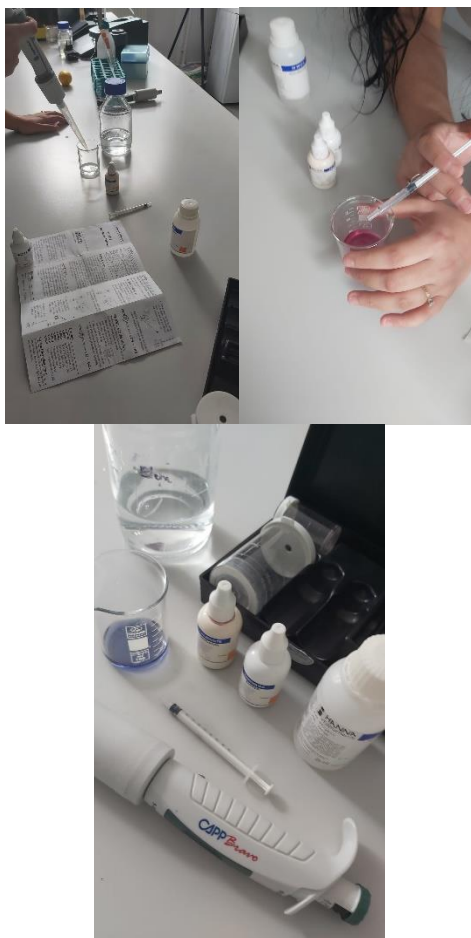


Figure 3. Hardness test

Defined substrate technology (DST) developed by IDEXX can produce results in 24 hours.

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Colilert can simultaneously detect these bacteria within 18-24 hours.

It can also suppress 2 million heterotrophic bacteria per 100 mL present.

The Enterolert Test from IDEXX uses a proprietary Defined Substrate Technology (DST) nutrient indicator to detect enterococci.

This nutrient indicator fluoresces when metabolized by enterococci. DST improves accuracy and avoids the need for hazardous sodium azide suppressants used in traditional media.

As of 2014, this technology from IDEXX has been published as a European Standard Method, and many countries now use this technology as their gold standard for water testing like Finland and Ireland.

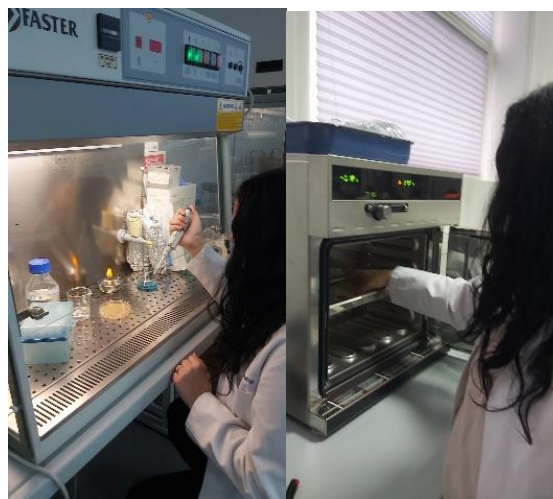


Figure 4. Microbiological indicators of the ground water

CONCLUSIONS

- All analyzes for water quality (colour, taste, smell, pH, turbidity, ammonia, nitrites and nitrates) from the private well fall within the maximum limits allowed by the standards in our country, except for the concentration of water hardness that exceeded the limits allowed.
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THE MONITORING OF EXPOSURE TO ENVIRONMENTAL NOISE

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Abstract

Environmental noise is a pervasive pollutant that adversely affects the health and well-being of European citizens and wildlife. Although noise is a product of many human activities, the most widespread sources of environmental noise are those related to transport. As a result, noise caused by transport is considered the second most significant environmental cause of ill health in Europe, behind fine particulate matter pollution (WHO and JRC, 2011; Hänninen et al., 2014). According to the World Health Organization (WHO), prolonged exposure to environmental noise is associated with an increased risk of negative physiological and psychological health outcomes (WHO, 2018). These include cardiovascular and metabolic effects, cognitive impairment in children, as well as severe annoyance and sleep disturbance. With projections of rapid urban growth and an increased demand for transport, a simultaneous increase in noise exposure and the associated adverse effects can be anticipated (Jarosińska et al., 2018).

The transposition of Directive 2002/49/EC of European Parliament and of the Council relating to the assessment and the management of environmental noise in Romania was achieved by Law no.121/2019 regarding the assessment and management of ambient noise. This law addresses the avoidance, prevention or reduction of harmful effects, including discomfort, caused by the population's exposure to ambient noise, through the progressive implementation of the following measures: the determination of exposure to environmental noise, through noise mapping, ensuring that information on environmental noise and its effects is made available to the public, adopting, based on the results of noise mapping, action plans to prevent and reduce ambient noise, where appropriate, in particular where exposure levels may cause harmful effects on human health, and to maintain ambient noise levels below defined limit values according to art. 4 point 19, if they are not exceeded. In order to evaluate noise pollution, common methods have been established at the level of the countries of the European Union. These methods evaluate environmental noise and define limit values, based on harmonized indicators to determine the noise level.

The purpose of this work is to present the importance of quiet green recreation areas for people's health. In order to achieve this objective, in this paper we present the method of obtaining comparative geospatial noise maps in crowded intersections (Arcul de Triumf and Casa Presei) and green areas (King Mihai I Park and Herăstrau Agronomy Campus) located in the northern part of Bucharest. To obtain the acoustic pressure values, we used the Sound Meter Coolexp application and a digital sound intensity measuring device - Uni-t UT353 sound meter. We used the obtained data to create geospatial noise maps with the QGIS application.

Key words: comparative geospatial noise maps, crowded intersections, green area, QGIS, Sound Meter Coolexp application, Uni-t UT353 sound meter.

INTRODUCTION

The transposition of Directive 2002/49/EC of European Parliament and of the Council relating to the assessment and the management of environmental noise in Romania was achieved by Law no.121/2019 regarding the assessment and management of ambient noise.

This law addresses the avoidance, prevention or reduction of harmful effects, including discomfort, caused by the population's exposure to ambient noise, through the

progressive implementation of the following measures:

- the determination of exposure to environmental noise, through noise mapping,
- ensuring that information on environmental noise and its effects is made available to the public,
- adopting, based on the results of noise mapping, action plans to prevent and reduce ambient noise, where appropriate, in particular where

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of obtaining comparative geospatial noise maps in crowded intersections (Arch of Triumph and The House of the Free Press and green areas (King Mihai I Park and Herăstrău Agronomy Campus) located in the northern part of Bucharest.

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MATERIAL AND METHODS

Table 1. dB values measured in intersections, parks, campus)

No.	Decibels (dB)	GPS Coordinates	Time of determinations
1	avg/70dB	44°28'44.1"N/ 26°04'21.4"E	14:48
2	avg/44,6dB	44°46'80.101"N/ 26°07'43.299"E	14:30
3	avg/69 dB	44°27'58"N /26°05'11"E	14:20
4	avg/56 dB	44°47'28.32"N/26°06'10.92"E	14:10
5	Avg/ 73 dB	44°46'74.28"N/26°07'75.19"E	14:00



Figure 1. Sound Meter Coolexp application interface



Figure 2. Sound Meter Coolexp application interface

Realization of the noise map

The noise map in intersections and green areas was made with the help of the QGIS application. This is a free professional GIS application that is also free and open source software (FOSS).

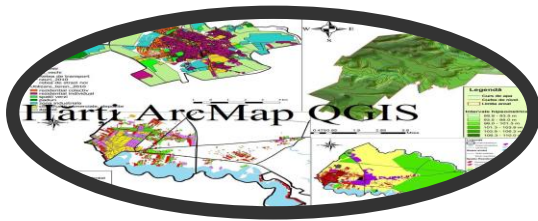


Figure 3. QGIS interface

The steps required to draw a noise map in QGIS are:

1. The data measured with the Cool application and the sound level meter are entered into Excel and saved in "CSV" format, so that they can be used in the QGIS program.

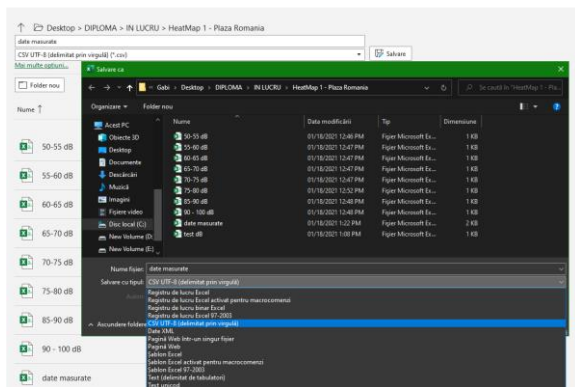


Figure 4. Saving data in CSV format

2. First of all, a "base map" is needed. This requires the use of the "QuickMapServices" or OSM plugin (as it is called in the toolbar). The plugin may already exist in the program or will need to be installed separately from the program's menu bar. After opening the plugin, the reference area can be searched.

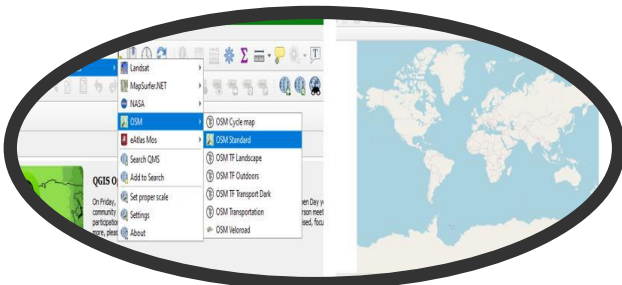


Figure 5. OSM Standard plugin (basemap)

3. After selecting the work area, the data taken in CSV format from Excel is added. To add the

Excel table, open the "Open Data Source Manager" menu. Enter the data table and press the "Add" button to place the reference points over the base map. After adding, the points will appear on the map.

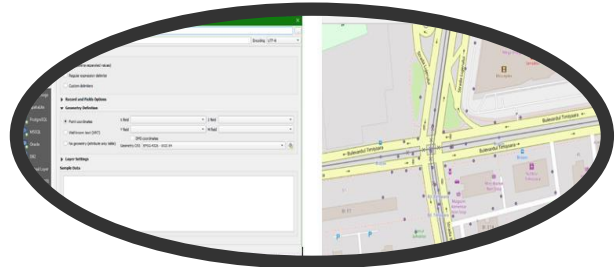


Figure 6. Data Source Manager menu and entering measured points on the map

4. Double-click on the "Layers" tab to open the properties window of the data table. Here the "Heatmap" option is selected to highlight the sound propagation on the map. The radius of the points must be selected, for this there are 2 options: separating the data into intervals, each interval corresponding to a table and a corresponding radius for that decibel interval; or keeping a single table in which the decibel intervals will be approximated by separate colors (example: green for 50-60 dB or red for 80-90 dB).

Points will have a larger radius depending on the decibel level measured at that point and the selected radius. In addition to all this, the column in the table representing the decibel values will be selected from the "Weight points by" option.

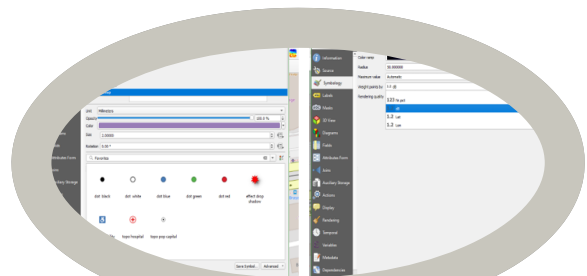


Figure 7. Heatmap menu and related settings

5. Finally, after adjusting the transparency of the points so that the base map can also be seen, adjusting the reference scale and selecting the desired colors.

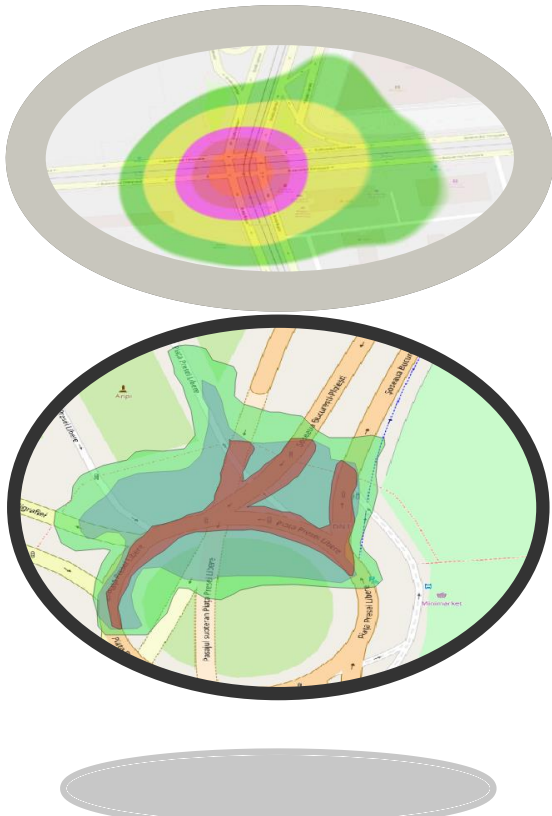
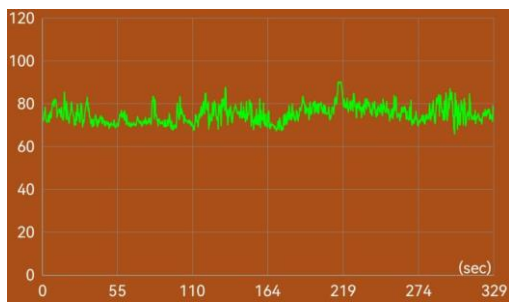


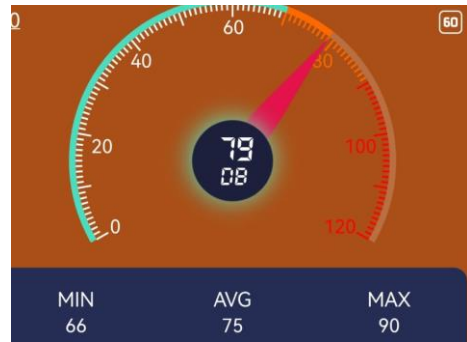
Figure 8. Noise map in QGIS

RESULTS AND DISCUSSIONS

Graphical interpretation of noise level values relative to time (the period of a single measurement).



Icons of noise levels measured over a certain period of time



-In the noise map, the roundabout at the "Piața Presei Libere" is represented.

-This area was intense affected by the traffic, pretty much at any time.

Probably this is why there aren't any school or residential apartment.

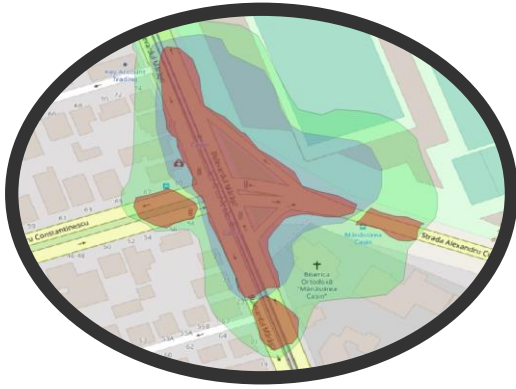
-The forest canopy from the Herăstrău Park reduce the noise pollution from the traffic.



- In the noise map, the Cașin intersection is represented.

- This area is not that highly noise polluted, but the public transportation by its kind (tram, bus) makes the zone to be affected.

-The buildings near the road (the houses, the rugby field, the church) dissipate the noise in much proportion.



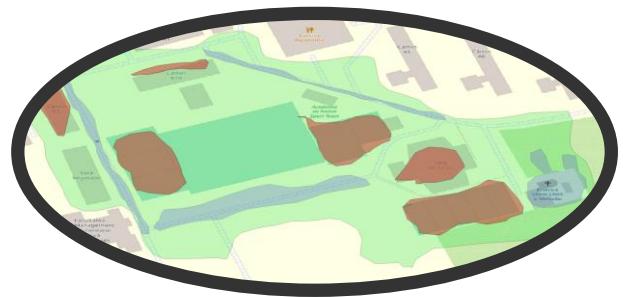
- In the noise map, the Campus University is represented.

-This zone is not much affected by the noise, there are no big boulevards or street and there is a quiet time period for all the residence.

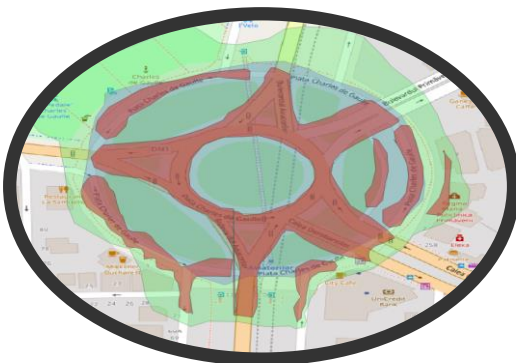
-In this perimeter the students are the most of the noise pollution factor which happens in the studying programs.



This is the roundabout “Charles de Gaulle” represented by the noise map.

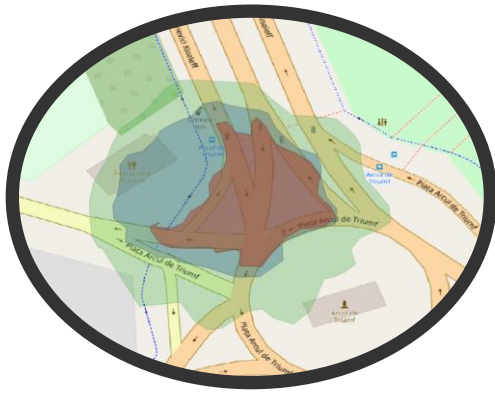


- There are many ambulances which travels a lot trough this roundabout because there is a big Hospital nearby.
- This is one of the busiest intersection in the north side of the capital.



This is the romanian “Arc de Triumf” - Arch of Triumph which is represented in the thermal map.

- This intersection is highly circulated because it connects some of the biggest boulevards in the city.
- Also in the middle of the intersection, there is a tourist attraction.



CONCLUSIONS

- ❖ In this paper, we present how to obtain geospatial noise maps and the differences that exist between areas with very intense traffic (crowded intersections - Arcul de Triumf and Casa Presei) and green areas where the noise level is very low (King Mihai I Park – Herăstrău Park and Herăstrău Agronomy Campus) located in the northern part of Bucharest.
- ❖ We recorded the noise level values with the Sound Meter Coolexp application and a Uni-t UT353 sound level meter.
- ❖ We graphically interpreted the obtained values and represented them in the form of graphs.
- ❖ We used the obtained data to create geospatial noise maps with the QGIS application.

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- <https://www.qgis.org/en/site/about/index.html>

REHABILITATION OF HYDROTECHNICAL WORKS OF AN IRRIGATION PLOT, BABADAG AREA, BABADAG COUNTY, TULCEA

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Abstract

This paper illustrates the current situation of the CA1 adduction canal, the possible technical solutions, the technical comparison between two waterproofing variants, the presentation of the rehabilitation works, as well as the main technological stages of the waterproofing of the canal in the Babadag area, county of Babadag. Tulcea. The two solutions that will be analysed are the following: the first solution consists in restoring the CA1 channel to its original dimensions and waterproofing it using the following technical solution: waterproofing using 235 g/m² geotextile + 0.75 mm HDPE geomembrane + C20/25, 8 cm concrete slabs, reinforced with welded mesh, and the second solution is restoring the CA1 channel to its original dimensions and waterproofing it using the following technical solution: waterproofing using EPDM geomembrane reinforced with polyester mesh.

The extension and rehabilitation of the irrigation infrastructure in Romania is expected to have a significant economic impact on the economic viability of farms, increase the competitiveness of farmers, but also support the agricultural sector to be able to face the long-term challenges of climate change, in particular those related to drought, as well as to ensure food stability and security in adverse climatic conditions. In the project we aimed to rehabilitate the hydrotechnical works of an irrigation plot in the Babadag area, we analysed the situation of the whole, we proposed general valid solutions for the condition of the hydrotechnical works and we customised to the situation and technical solutions suitable for the CA1 canal. We have analysed its transport capacity, finding that, if it is decolmated, it meets the flow conditions required for operation, but with a higher water level at the required flow rate.

Key words: adduction, canal, geomembrane, geotextile, irrigation, land reclamation, waterproofing.

INTRODUCTION

In order to ensure sustainable economic development in rural areas, the analysis of the current situation in Romania shows that it is necessary to accelerate the process of modernisation/structural adjustment of agriculture, land improvement and rural development.

Romania's rural economy is dominated by agriculture, but is not yet well integrated into the market economy.

In Romania, the territory totals 23.8 million ha and the agricultural area of the country is 14.7 million ha (61.7%), of which about 2/3 of this agricultural area suffers from drought, excess moisture and soil erosion, causing damage to agriculture every year.

Land improvement works aim at eliminating

the negative effects of climate change as described above and are classified into: works to eliminate soil water deficit by means of irrigation; works to prevent and combat soil erosion; works to prevent and combat excess water: dyking, drainage-drainage and regularisation of watercourses.

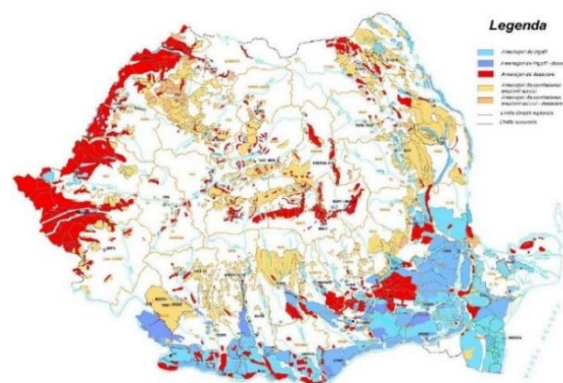


Figure 1. Situation of functional, contracted and irrigated areas during the period 2006 – 2018

water intake; the conveyance, distribution and irrigation network; the collection and disposal network; the constructions and installations on the canal network and special constructions and installations.

According to their degree of technical sophistication, irrigation systems can be divided into three categories: rudimentary, semi-rudimentary and advanced.

According to the method of water transport, irrigation systems are divided into: open (with open channels), closed (with pipes) and combined (large open channels and small closed channels).

Irrigation systems are further classified according to the method of receiving water: gravity-fed, mechanically lifted and mixed irrigation systems.

In terms of operating time, irrigation systems are divided into: permanent irrigation systems; periodic irrigation systems.

The canal network of the irrigation system is intended to provide: water supply and distribution to the irrigated land to compensate for moisture deficit and other uses; collection and discharge of surplus water from the irrigated land and other uses.

The irrigation system includes two categories of canals: the adduction and irrigation network; the collection and drainage network for desiccation.

The adduction and irrigation network is designed to convey water from the water source to the irrigated land, where the transition from the current state to the wet state will take place.

A system's network of supply and irrigation canals is divided into: permanent network and temporary network. The issue of waterproofing irrigation canals depends on a number of objective requirements, such as: the need to minimise water losses due to seepage; prevent silting of adjacent land and reduce drainage costs; reduce the size of canals and the cost of engineering works; reduce maintenance and operating costs.

The lining of water storage ponds and irrigation channels can be done with different types of sheeting (membranes), protected with concrete slabs, which is the solution unanimously accepted by experts.

Geomembranes are thin, flat, polymeric products in the form of sheets with very low permeability, used for waterproofing (sealing) in contact with soil or other materials.

Geomembranes are successfully used in: waterproofing of waste water treatment, storage and purification basins; waterproofing of water reservoirs, ponds and artificial lakes; waterproofing of canals, earth dams and tunnels; hydro-engineering and water management constructions; land improvement constructions, etc.

MATERIALS AND METHODS

From a technical point of view, each of the options has a number of advantages and disadvantages, which are summarised in the table below:

Table 1. Technical comparison between variants

Nr. Crt.	Varianta	Avantaje	Dezavantaje
1	geotextil 235 g/m ² + geomembrană din PEID 0,75 mm + dale din beton C20/25, 8 cm, armat cu plasă sudată	- rezistență chimică excelentă; - îmbinare ușoară prin încălzire și extrudare; - cost redus; - gamă largă de grosimi; - poate avea ambele fețe netede sau poate să fie rugoasă pe o față sau pe ambele fețe; - rezistență remarcabilă la radiațiile UV; - poate fi instalată în condiții diverse; - are proprietăți de frecare excepționale.	- suprafață lisă cu frecare redusă; - sensibilă la fisuri din solicitări; - contracție/ dilatare termică mare.
2	geomembrană din EPDM întărit cu plasă de poliester	- comportare bună la factorii climatici; - greutate redusă când se realizează dintr-un singur strat; - bună rezistență la fisurarea la rece; - rezistență chimică bună.	- performanțe slabe la temperaturi ridicate; - presupune echipament special pentru îmbinare; - repararea pe șantier este dificilă.

Proposed rehabilitation works

Canal CA1 – L= 4.035 m

Technical characteristics of the adduction canal CA1:

Length (m)	4.035,00
Surface (m ²)	33.268,50
Debit (m ³ /s)	12,32
Slope invert (%)	0,1
Raft width, b (m)	2,5
Inner buttress	1:1,5

1) Recalibration of the channel section by clearing overgrown vegetation on the embankments and channel invert and removing debris down to the existing slabs; Once the

spoil has been removed, it will be deposited on the left bank, filling in the existing soil wave.

2) Filling voids in existing slabs with sand and repairing sharp edges in the existing wall with repair mortar;

3) Waterproofing of the channel using 235 g/m² geotextile + 0.75 mm HDPE geomembrane + C25/30 concrete slabs, cast in place 8 cm, 6 m slab length, reinforced concrete with welded mesh D=4 mm. The new wall on the slabs will exceed the top of the existing wall by 25 cm.

4) 2 cm/8 cm backfill filled with sand (4 cm) and modified bitumen mastic with added rubber or equivalent (4 cm);

5) The 5 areas of collapse (km 1+870, km 2+612, km 2+644, km 3+168, km 3+408) will be remedied by removing unstable slabs, filling with local material from borrow pits without topsoil, creating twinning steps and compacting them to the level of the existing slabs.

The dismantled slabs will be transported to a landfill site chosen by the beneficiary for reuse or to a landfill for construction waste.

6) In the vicinity of hydrotechnical constructions, the geotextile and geomembrane shall be anchored as follows:

- a trench 25 cm deep and 1.5 m wide shall be dug along the entire length of the channel cross-section, the area of the tiled wall, up to the base of the hydrotechnical construction;

- place the geotextile and geomembrane;

- pour the concrete up to the level of the new slabs, resulting in a total thickness of 25 cm + 8 cm.

7) The 5 areas with breaks in the earth wave protecting the channel (km 2+644, km 3+168, 3+283, km 3+360, 3+868) will be repaired. The repair consists of completing the earthworks to restore the wave profile.

8) The culvert at km 0+306 will be cleared.

9) The storm water discharge area at km 1+505 will be closed and the section of pipe perpendicular to the canal in the ANIF management area will be decommissioned.

10) Concrete repairs at spillway km 3+990;

11) The slopes above the new concrete wall;

Main technological stages of sewer waterproofing

- the marking of the channels, with the placement of concrete kilometre and hectometre markers;

- manual and/or mechanical clearing;

- clearing of channels of deposits and vegetation;

- spreading the resulting soil on the existing protective wave / filling in the gaps in it;

- finishing the slopes above the wall area;

- excavations for anchoring geotextile and geomembrane above existing slabs;

- filling the missing spaces between existing slabs with sand;

- grinding the surfaces of existing slabs with repair mortar in order to avoid sharp edges in the geosynthetic backing layer;

- laying the geotextile across the channel with the associated overlaps and anchoring;

- laying and installation of the geomembrane, including wind protection measures and the establishment of traffic restrictions on the installation materials;

- careful placement of reinforcement mesh using spacers that do not affect the geomembrane and concrete casting, including in anchors;

- watering the concrete in the wall and protecting it;

- treatment and closure of joints;

- grassing of channel slopes above the concrete wall.

Calculation of transport capacity

I checked the carrying capacity of the existing section to see if recalibration was needed.

$b = 2,5$ m (the bottom width of the canal)

$h = 2,1$ m (height/depth of water in the canal)

$h_{\text{guard}} = 0,75$ (existing slab) + 0,15 (elevation) = 0,90 m

$m = 1,5$ (embankment slope)

$n = 0,034$ (roughness)

$i = 0,1\%$ (hydraulic slope)

$P = b + 2 \times h \times \sqrt{1 + m^2}$ (wetted/wetted perimeter, m)

$P = 10,07$ m

$\omega = h \times (b + m \times h)$ (flow section, m²)

$\omega = 11,87$ m²

$R = \frac{\omega}{P}$ (hydraulic radius)

$R = 1,18$ m

$v = C \times \sqrt{R} \times i$ (flow speed, m/s)

$C = \frac{1}{n} \times R^{1/6}$ (Chézy's coefficient, m^{0,5}/s)

$$C = 30,23 \text{ m}^0,5/\text{s}$$

$$v = 1,04 \text{ m/s}$$

$$Q = \omega \times v \Rightarrow Q = 12,32 \text{ m}^3/\text{s}$$

In the existing channel it is sufficient to return to the original section by dewatering with the proviso that the maximum water level will be raised, which makes it necessary to raise the water level of the section on the slopes.

Channel exfiltration for different hypothesis

The numerical modelling of the flow process in a porous medium beneath the CA1 channel slopes was carried out using the calculation program called SEEP/W, from the GEOSLOPE 7 software package - developed by the University of Saskatchewan - Canada, specialized in the study of flow through porous media.

We initially defined all existing material types and assigned all material types:

- Loess (orange), with permeability $k = 10^{-7} \text{ m/s}$
- Geotextile (black), with permeability $k = 6 \times 10^{-2} \text{ m/s}$ and thickness 1,4 mm.
- Geomembrane (yellow) with permeability $k = 10^{-14} \text{ m/s}$ and thickness 2,2 mm.
- Concrete (grey), with permeability $k = 10^{-9} \text{ m/s}$
- Water (blue)

Results obtained and their interpretation

We considered 3 situations of lining with:

- 1) Geomembrane (proposed solution)
- 2) New concrete wall
- 3) Degraded/porous wall (initial solution)

For each of the 3 situations we obtained the following:

Situation 1 - with geomembrane: $1,06 \times 10^{-20} \text{ m}^3/\text{s.m}$

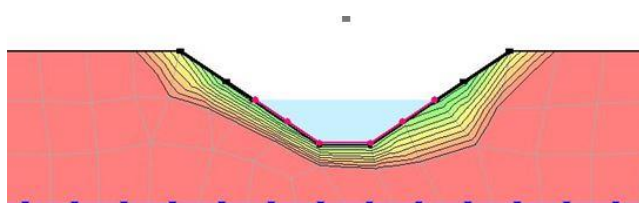


Figure 6. Equal hydraulic load lines

Situation 2 - new concrete wall: $2,32 \times 10^{-17} \text{ m}^3/\text{s.m}$

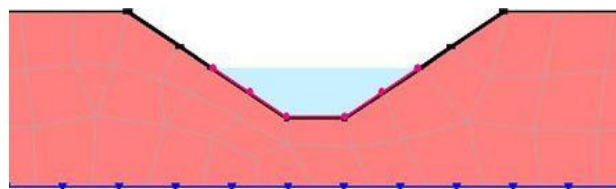


Figure 7. Equal hydraulic load lines

Situation 3 - existing degraded/porous wall: $2,65 \times 10^{-15} \text{ m}^3/\text{s.m}$



Figure 8. Hydraulic equal load lines

RESULTS AND DISCUSSIONS

Comparing the flow values obtained by summing the flows on the elements composing the channel contour, I find that the difference between the proposed solution and the initial solution is 5 orders of magnitude, which means that the exfiltrated flow in the variant using the new concrete wall is 100 times lower than the existing situation (with degraded wall), and if I use the solution with geomembrane waterproofing, the exfiltrated flow decreases by 100,000 times.

CONCLUSIONS

Consequently, the solution I advocate is to maintain the channel at its original dimensions, waterproofing using the following technical solution: waterproofing using 235 g/m² geotextile + 0.75 mm HDPE geomembrane + C20/25, 8 cm concrete slabs, reinforced with welded mesh.

The benefits and advantages of these rehabilitation works are numerous, such as: optimal flow carrying capacity, reduction of drainage costs and prevention of silting of adjacent land, water lost through exfiltration is reduced to the maximum, maintenance and operation costs are reduced, an important factor, but also macroeconomic effects that will be generated thanks to the rehabilitation of the main irrigation infrastructure. These consist of a net income increase compared to the previous rehabilitation situation due to improved land

productivity, improved cropping plan structure and higher average production per hectare. In conclusion, the project I have submitted to you will, through all the benefits mentioned, lead to sustainable agriculture.

CONTRIBUTIONS

Under the guidance of coordinating professor Assoc. Prof. PhD Eng. Augustina Tronac, the author conducted the research described in this paper in the Irrigation Laboratory of the Faculty of Land Reclamation and Environmental Engineering.

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THE WONDERS OF THE MICROBIAL WORLD – STATE OF THE ART

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Abstract

In this paper we want to present a short review about the amazing activity of microorganisms, which does not cease to surprise us and the various fields of activity where they can be used. Due to the fact that microorganisms have existed on earth for almost 4 billion years, they have been able to develop very complex metabolic pathways that have allowed them to occupy various ecological niches and survive. Also, the complex relationships that have been established over time between different types of microorganisms, and that have begun to be discovered and understood by researchers, open new perspectives for the development of new technologies and environmentally friendly products.

Microorganisms continue to amaze us with their incredible properties: they can be excellent builders, producers of natural pigments for nontoxic dyes, producers of nanoparticles and nanomaterials, purifiers of contaminated air, water and soil, skilled decomposers of countless chemicals (even xenobiotic), recyclers of matter in biogeochemical cycles, etc.

In this paper we will draw attention to how microorganisms can be included in state of the art technologies and products that help the sustainable development of human society in the near future. Thus, we will talk about: eco-friendly biological bricks, building materials from mycelium, biocomposite, the healer fungus, algae-grown limestone concrete, electricity-generating bio-panels, fungi for everyday products, natural microbial dye, bacteria and amazing spider silk.

Key words: *algae-grown limestone concrete, bacteria and amazing spider silk, building materials from mycelium, biocomposite, the healer fungus, eco-friendly biological bricks, electricity-generating bio-panels, fungi for everyday products, natural microbial dye.*

INTRODUCTION

Microorganisms continue to amaze us with their incredible properties:

- ✓ they can be excellent builders,
- ✓ producers of natural pigments for nontoxic dyes,
- ✓ producers of nanoparticles and nanomaterials,
- ✓ purifiers of contaminated air, water and soil,
- ✓ skilled decomposers of countless chemicals (even xenobiotic),
- ✓ recyclers of matter in biogeochemical cycles, etc.

Moreover, microorganisms can be used in HCI applications – Human Computer Interaction.

Human Computer Interaction

The integration of living organisms into

interactive systems is a growing area of interest for HCI and design researchers.

Organisms have been embedded in interactive installations, hybrid computer games, wearables and interface designs, in which novel functionalities and interaction possibilities are achieved through substitution of computer input and output with living media.

The ability of living organisms to dynamically change the color of an artefact has been harnessed in diverse ways in HCI and design, for example, through pigment producing bacteria, fluorescent bacteria or bioluminescent algae.

Flavobacteria can add to this repertoire by changing the color of an artifact through their structural color. These bacteria, which can be found in marine environments, are able to grow as part of a densely organized colony. Through this multicellular organization, they form photonic crystals which reflect light in specific

ways, creating striking visual effects. Microbiologists have researched *Flavobacteria's* ability to self-organize in relation to various abiotic factors, the presence of other microbes, etc. However, despite their vivid colorations and highly responsive behavior, *Flavobacteria* are yet to be explored as a living medium for human-computer interaction design.

Eco-friendly biological bricks

Start-up company BioMason is currently working towards a debut of a new kind of eco-friendly brick 'grown' with sand and bacteria. The construction industry currently accounts for around 40% of work emissions. Used in over 80% of building construction projects, bricks are a large contributor to this, generating approximately 800 million tonnes of carbon emissions per year, which more than the amount produced by all the planes in the world each year. That is a lot of pollution from one relatively simple material.

BioMason's eco-friendly bricks also use the natural process of calcification to gain their structure and strength. To create the bricks, sand is put into a mold and then inoculated with bacteria (*Sporosarcina pasteurii*). These bacteria are fed with calcium ions suspended in the water. The ions are attracted to the cell walls of the bacteria, creating in a calcium carbonate shell and the basis for a strong brick. Unlike traditional bricks that requiring days of firing and produce large amounts of emissions as a result, BioMason's biological bricks are grown in only two to three days – and they are emission free. As an added bonus the bricks can actually even absorb pollution and include other characteristics such as glow in the dark and colour change properties.

Natural microbial dye

Fashion colours change each year, yet one thing doesn't seem to change: the polluting nature of dye, leaving whole rivers dirty with chemicals and pigments.

Fabulous bacteria & fungi are the solution to one of the major problems in the fashion industry; the use of synthetic textile dyes. Enormous amounts of harmful chemicals are

involved with this conventional dyeing method, which causes water pollution, health problems and a significant demand of water and energy. Fabulous bacteria & fungi employ microorganisms in order to create sustainable and safe textile dye, without the use of harmful chemicals.

One solution to these harmful dyes may be found in bacteria & fungi. Pigment-producing bacteria & fungi do not require harmful chemicals for the dyeing process.

The biochemical processes of these bacteria and fungi produce pigments. These pigments, which form the basis of the textile dye, are biodegradable. This means it won't cause any water pollution. In addition, bacterial and fungal dyes require less water and energy. All in all, bacterial and fungal dye will have many benefits over synthetic textile dye and other alternatives.

Building materials from mycelium

Durability

Biohm believes that materials should be made to last as long as their intended use and that sustainable and circular end-of-life considerations should be embedded into the product itself. Independent insitu testing of mycelium has demonstrated that they are at least as durable as conventional materials and retain their performance over their life. The material can then be fed back into the manufacturing process or otherwise cold composted.

Biocomposite

One of the interesting biocomposites, the object of research at the CoEBBE, is called Nabasco. This is a composite that consists of a resin, a fibre and a filler. The ingredients can vary depending on the desired properties and esthetics.

The healer fungus

Researchers at Binghamton University & Rutgers University are working on a solution for broken concrete. They discovered that adding fungus to the mix could cause the

concrete to heal itself.

Concrete expands and shrinks during everyday use, because of heat and moisture, which causes the concrete to crack. Microcracks can allow water and oxygen to infiltrate, which, in case of reinforced concrete, can cause the steel to corrode.

The researchers started looking for a way to create a concrete that can heal itself, like a living organism. They found an unusual candidate for the job: a fungus called *Trichoderma reesei*.

As the calcium hydroxide from concrete dissolves in water, the pH of the fungal growth increases from a close-to-neutral value to one that is very alkaline. Of all the fungi tested only *T. reesei* survived that environment. Despite the pH increase, the spores keep germinating to mycelium. *T. reesei* is eco-friendly and nonpathogenic, posing no known risk to human health.

Electricity-generating bio-panels

Mexican start-up Greenfluidics developed a solar bio-panel that integrates CO₂ capturing, the production of oxygen, and the production of energy through the use of micro-algae.

Photosynthesis is a natural process by which plants and algae produce energy, organic matter and oxygen using sunlight and carbon

dioxide from the atmosphere. This process is what powers the bio-panels. Greenfluidics says that the algae mitigate from 200 kg CO₂ per year.

The algae in the semi-transparent green panel are combined with nanofluids, which take solar radiation and absorb high temperatures, creating energy. The triangular design can be installed on any type of structure.

Each bio-panel is said to be able to generate up to 328 KWh/m² per year. In addition, due to the thermal comfort that it can provide to buildings, up to 90 KWh/m² per year can be saved.

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ECOLOGICAL RENATURATION PROCESS OF THE ZAGHEN POLDER IN TULCEA COUNTY

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Abstract

The article presents the evolution of the ecological renaturation process of the Danube riverbed on the territory of Tulcea county, namely the Zaghen Polder. The economic, geostrategic and biodiversity importance of the Danube valley has been written about since ancient times, and in 1910 the Roman researcher Grigore Antipa drew attention to the negative effects that the damming and draining of these wetlands for agricultural exploitation would have in the future. Following the historic floods on the Danube in 2006, this subject was reopened and as a result the Romanian legislators issued Decision no.1208 of 6 September 2006 approving the ecological and economic resizing programme in the Romanian sector of the Danube River Basin and its financing. The WWF International organisation, which campaigns for the implementation of the projects together with local decision-making institutions such as the ADDBR, provides important support in this process. A concrete example of the ecological restoration of a dammed area on the Danube is the Zaghen polder.

Key words: Danube meadow, ecological renaturation, habitat, hydrotechnical works, Zaghen polder.

INTRODUCTION

Ecological restoration is the process of restoring a degraded, damaged or destroyed ecosystem. It can involve the restoration of degraded land, renaturation processes in areas affected by extractive activities or pollution, as well as the reintroduction of species or the revitalisation of habitats in areas where land cover or population size has been significantly reduced by human actions (<https://wwf.ro/ce-facem/ape-dulci/reconstructie-ecologica/>).

Dumitrescu and Carsmariu (2014) have presented in an article on the development wetlands, the study aimed at the ecological restoration of Zaghen Lake. This wetland is located in the eastern region of Tulcea. Geographically, Zaghen Lake is located adjacent to the towns of Tulcea, Malcoci, Nufăru, and the area under reconstruction is about 200 ha. The Zaghen area is part of the Danube Delta Biosphere Reserve territory, and this territory of the Delta is a World Natural Heritage site.

It is claimed that, without these reconstruction and renaturation works, the lake enclosure will

be an unhealthy and unattractive area for tourism on the one hand and, on the other hand, it will not be able to function to take the water flows from the floods.

In order to support the importance of reconstruction of the enclosure Zaghen, Administration of the Danube Delta Biosphere Reserve (ADDBR) in partnership with the Tulcea City Hall have developed a project containing the most important benefits for the local community and the fauna of the area (Dumitrescu and Carsmariu, 2014).

MATERIALS AND METHODS

The main functions of the floodplain are ecological, socio-economic but not in last row the biogeochemical (Mircea, 2012).

The aim and objectives of the proposed project are the following:

1. Restoring the natural habitat specific to the Danube Delta, namely the wetlands, by creating a favourable climate in which flora and fauna can develop natural resources such as: reeds, reeds, fish, birds (Dumitrescu and Carsmariu, 2014);

2. Maintaining the usefulness of the lake in mitigating floods in Tulcea Municipality (Dumitrescu and Carsmariu, 2014);

3. Maintaining the optimal level in Zaghen Lake by pumping/draining water from/into the Danube (Dumitrescu and Carsmariu, 2014).

Based on the above mentioned aims and objectives, a series of specific construction and hydrotechnical works were undertaken (***2011).

These works ensure optimal conditions for the maintenance of a wetland ecosystem by creating a permanent water table and terrestrial refuge areas. The water level will be constant/fluctuating within the limits set by the contour dykes, but will also ensure the capture, retention and transit of floods with a probability of exceeding 1%, together with the two upgraded pumping stations (***2011).

Site works

State-of-the-art machinery and equipment have been used, which comply with standards regarding pollutant emissions and low environmental impact. The materials used to carry out the works were those characteristics of the area, i.e. the material resulting from excavation, decolourization, scraping, rectification of the riverbed, was used for the filling works (***2011). In Figure 1 we can see the work done at Zaghen Polder.



Figure 1. Works carried out in Polder Zaghen (<http://www.coralconstructii.ro/en/rezervatia-biosferei-delta-dunarii/>)

The hydrotechnical works carried out within

the project initiated by ADDBR, according to the Environmental Impact Report for the Ecological Reconstruction Project in the Zaghen Polder of the Transboundary Biosphere Reserve Danube Delta Romania/Ucraina, 2013, foresee the following specific works:

1. Ecological reconstruction of specific habitat types of delta ecosystem (extension of the water span, creation of refuge areas);

2. Creation and control of the Zaghen Lake water regime;

3. Rehabilitation of the Zaghen – Danube connecting canal.

The connection of Zaghen Lake with the Danube is made by an artificial reversible channel of about 3200 m length, of which the actual channel is 3095 m long, the rest being areas connecting to the pumping stations (Figure 2).



Figure 2. Polder location towards Danube River and connecting channel (***2011).

RESULTS AND DISCUSSIONS

In accordance with the Decision of the Tulcea Local Council No 8/29 June 2016 the completion of these works led to the expected results, thus fulfilling the project's purpose and objectives. Therefore, the Zaghen polder has the following functions: biogeochemical, hydrological, socio-economic, and of course ecological function. Thus, if we refer to the hydrological function, the lake enclosure is involved in alluvial catchment. From a biogeochemical point of view, the lake takes

up, retains and recycles certain nutrients, including phosphorus and nitrogen, as well as denitrification through the mineralization of organic pollutants, thus ensuring a natural carbon cycle, and an anoxic regime is maintained at the surface layer of the soil (Suliman et al., 2019).

Following the completion of the ecological restoration works in the Zaghen area, which was aimed at initiating or accelerating the recovery of ecosystems, major changes were made in the physical as well as in the biotic component (Marinov et al., 2021).

Ecological functions

From an ecological point of view, the Zaghen polder is a habitat for flora and fauna, it has become an ecosystem in which animals can manifest their essential functions, reproduction and development, as well as feeding. It has also found that the Zaghen polder offers migratory birds the right conditions for life (Figures 3, 4 and 5).



Figure 3. Wild duck (<https://filmaridrona.ro/>)



Figure 4. Wild duck (<https://filmaridrona.ro/>)



Figure 5. Crested Pelican (<https://filmaridrona.ro/>)

At the same time, zooplankton and phytoplankton regeneration took place, macrophytes and microbial biofilms are essential in the decomposition of plant waste, but also in the nutrient recycling process as macrophytes regulate microbial metabolism (Suliman et al., 2019).

The socio-economic function has been fulfilled, since the premises lake a contributed to the development of ecotourism, becoming a place of recreation, but also to education, by raising awareness of the importance of maintaining it in optimal parameters (Figure 6). It is possible to practise occupations specific to the area, collect plants, harvesting reeds and of course, fishing. So Zaghen has become a habitat for a population that has not been able to keep up with progress but is familiar with all that the delta space means (Suliman et al., 2019).



Figure 6. Polder Zaghen - drone view (own photo)

CONCLUSIONS

The findings of this study showed that the Zaghen polder can recover and manifest its intended functions. Definitions mark this term as an enclosure of land, torn from either a sea or a lake, dammed and used in agriculture. In addition to its contribution to agriculture, it enjoys three other important benefits to the community, providing a habitat for plants and animals as well as a favourable ecotourism context for people.

The results showed that this 200 ha area undergoing ecological reconstruction was a real success, as it led to the conservation of biological diversity, maintenance of natural habitats and protection against flooding.

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FOOD FOR A SUSTAINABLE FUTURE

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Abstract

In recent years, attention has been focused on the constant trend of population growth, and the consequent growing demand for food, which classic agriculture can no longer provide. Alternative food like insects, red seaweed, soy, and cell-based products are a sustainable way of changing our diet in order to minimize the environmental impact determined by greenhouse emissions, water, land, and energy use. Consumption of these alternative foods comes new industry vision of what the future of food will look like, and as a result with new regulations. Being novel foods, most people don't have enough knowledge and consider unnatural these new methods of producing them. Surprisingly, alternative foods are particularly rejected by Western societies, which proves that culture impacts a good amount of our beliefs. This current mini-review focuses on explaining what cellular agriculture is, what aliments are considered alternative food and whether we could reach a sustainable future by changing our diet.

Key words: *alternative food, cell-based meat, cellular agriculture, sustainable food, soy protein.*

INTRODUCTION

In recent years, increasing attention has been paid to agriculture and the development of the food industry. It has been brought to attention that classic agriculture will not be sufficient for our growing population without permanently damaging our environment.

In 2012, The Food and Agriculture Organization (FAO) of the United Nations predicted that by 2050, with an estimated population of 9.8 billion, the global demand for meat would be 76% more than in 2005 (455 M metric tons of meat), with only 2% agriculture land left. Therefore, the design and production of alternative foods have been intensively studied (Rischer et al., 2020; Rubio, et al., 2020). The European Commission designed the "Farm to Fork Strategy", to establish a healthier food system, indicating multiple actions, like reducing chemical pesticides by 50% and fertilizers by 20% and increasing ecological production from land use to 25% by 2030.

Currently, the food industry is known to be one of the major contributors to environmental problems, accounting for approximately 21-37% of global greenhouse gas emissions (Alae-

Carew et al., 2021).

The aim of this review is to briefly explain what cellular agriculture is, what aliments are considered alternative food and whether we could reach a sustainable future by changing our diet.

MATERIALS AND METHODS

The methodology for the article collection contained the survey of one scientific data-base (ScienceDirect) for the published research data until March 2023. Only papers written in English were considered, dating as far back as 2011. The electronic search was performed using as specific keywords: alternative food, soy, red seaweed, insects resulting in a total of 371 articles, cellular agriculture, CBM, organoleptic properties resulting in a total of 11 articles, and cellular agriculture, CBM resulting in a total of 594 articles. Title and abstracts retrieved by these searches were screened for relevance and deduplication. The 25 selected articles were classified by article type (original research or review) and the validation was performed manually (by reading the entire article).

ALTERNATIVE FOOD

The 2018 Report published by the Intergovernmental Panel on Climate Change (IPCC) claims that by 2030, greenhouse gas emissions (GHG) need to decrease by up to 45% to avoid a 1.5°C temperature increase; it is also stated that these problems are mainly caused by animal agriculture through land, water, and energy use, as well as methane emissions (Rubio et al., 2022).

In recent years it has been highlighted that consumers are looking for alternative foods for a sustainable future, with alternative proteins such as those extracted from plants, insects, algae and soy playing an important role in replacing animal proteins (Michel et al., 2021).

RED SEAWEEDS

Red seaweeds are one of the oldest and largest eukaryotic algae, with approximately 6500 known species, some of them being used around the globe for human consumption. They are very popular around Asian countries. For example, algae of the *Porphyra* genus are used as sushi wrappers (also known as Nori) (Rawiwan et al., 2022), and *Palmaria palmata* (dulse) is used as an ingredient in food processing (Mouritsen et al., 2013).

Red seaweeds have essential amino acids that can replace in a sustainable way animal protein. They provide high protein content, along with vital vitamins and minerals. Being spontaneously found in fresh water as well as marine water, they present an easy and sustainable way of cultivating them. *Palmaria palmata* could be cultivated on land, in pools and in the sea (Rawiwan et al., 2022).

Raw algae must be subjected to several treatments in order for the contained proteins to become valuable. Pre-treatment methods such as freezing, ensiling, and drying have been studied on red seaweeds, as well as different types of extractions. Every species of red seaweed has its different properties that require special extraction and harvest technique (Rawiwan et al., 2022).

INSECTS AS FOOD

It is well known that cows produce large amounts of methane, and it is currently debated whether it is still rational to maintain cow farms in the farming industry. Thus, scientists began to study insects as a reliable protein source.

This idea was not well received at the beginning by western society, but at the moment there are 113 countries that are using insects as a source of proteins in different foods (Govorushko, 2019).

Looking from a sustainable point of view, insects are an efficient raw source, spending less energy and water and producing less GHG than other livestock. (De Carvalho et al., 2019). Most edible insects are harvested from their natural habitat (92%), a small part are semi-domesticated (6%), and only 2% of edible insects are farmed (Madau et al., 2020).

As stated before, the main component of insects is protein. The protein content can range from 23% to 76% (found in the adult locust). Protein absorption, not that well tested, is believed to fluctuate from 77% to 98% for 78 species. (Hawkey et al., 2020). On the other hand, every year insects are killed to save crops that have at most 14% protein content, while the slaughtered insects contain up to 75% high-quality animal protein (Madau et al., 2020).

Moreover, there are studies that demonstrate that animals consume more food than they produce. An additional kilogram of beef requires 10 kg of feed, 2.5 for chicken and 5 kg for pork, respectively, while insects require merely 1.7 kg of feed (Govorushko, 2019).

SOY PROTEINS

Plant-based meat (PBM) is a completely vegetal product, obtained by transforming plants into products that resemble animal meat, and containing an optimal ratio of vitamins, fats, proteins, and minerals (Good Food Institute, 2021). According to New Nutrition Business, in 2020, PBM ranked 3rd in global food trends. The increase in the consumption of PBM has an important impact both on the environment, and on reducing the risks of diseases (Estell et al., 2021).

An excellent option to produce PBM is soy protein, because of its processing characteristic, good nutritional value and low cost. In order to obtain a soy-based meat alternative, the production process must include the addition of wheat gluten to bind and stabilize the structure of soy protein fibers, improve the flavor, but also to help build the structure (Wang et al., 2023).

Initially used as animal feed, soybean crops began to be used for the manufacture of oil and other types of food products only after the Second World War (Institute of Agriculture and Natural Resources, 2020). Currently, numerous products can be obtained from soybeans, such as: soy milk, which is a rich source of B12, D vitamin complexes; tofu acting similar to yogurt; soybean oil, soy sauce, etc. (Wang et al., 2023).

REGULATORY FRAMEWORK

Because alternative food is regarded as a relatively new concept, regulatory frameworks are not yet well established. Labelling rules are contained in the Food Information Regulation EU/1169/2011, which stipulates that every ingredient must be catalogued (Lähtenmäki-Uutela et al., 2021).

EU policy and regulations approve investment in alternative proteins; therefore, the European Commission announced in 2018 the EU Plan for Proteins, which urges the production of alternative foods for human consumption and offers alternatives to strengthen the development of plant proteins in the EU (Rubio et al., 2022).

Classical PBMs have been accepted for population consumption as they contain simple ingredients which have already been approved; in case of novel ingredients, they must be subjected to individual evaluation (Rubio et al., 2022).

Red seaweeds can absorb heavy metals due to their strong accumulation capabilities. To ensure safety, red seaweed must be thoroughly inspected in case of contamination during processing (Rawiwan et al., 2022).

Regarding insects, the new European Novel Food Regulation is applicable for whole insects, insect flour, and insect parts, since 2018 (Lähtenmäki-Uutela et al., 2021).

CELLULAR AGRICULTURE

FAO defines cellular agriculture as the cultivation of cells isolated from animals, followed by processing to produce food products that are comparable to the corresponding animal versions, such as meat, poultry, aquatic products, dairy products, and eggs.

Therefore, cell-based meat (CBM) deals with the production of meat from isolated and lab-grown cells, thus avoiding the current practice

of animals' slaughter. The development of CBM is a complex process, consisting of several stages. Initially, muscle stem cells are harvested from animals and cultured in a suitable environment. Tissue engineers assemble muscle tissue, then adult cells are selected and placed on a framework into a bioreactor to grow. After that, the product is subjected to special treatments to achieve similar organoleptic characteristics to animal-based meat (ABM), and finally, CBM is ready to be consumed (Siddiqui et al., 2022).

In terms of nutritional value, it is well known that ABM contains minerals, vitamins, and amino acids, while there is no publicly available data for CBM. It is known that CBM contains proteins like collagen and fibrin, but, for example, vitamin B12 will have to be supplemented, being only produced by bacteria (Rubio et al., 2020; Siddiqui et al., 2022). In order for CBM to be as similar as possible to ABM there are three factors that are looked upon: texture, taste and appearance. The lack of myoglobin protein in CBM leads to the lack of naturally existing red colour in the ABM. To fix this problem, natural colorants like sugar beet or saffron are introduced in CBM production (Siddiqui et al., 2022). Texture can be replicated by eliciting alignment during the engineering process (Rubio et al., 2020).

Even if the production process is difficult and expensive, however, CBM has numerous benefits for humane health. While ABM is associated with antibiotic resistance and foodborne infections like Salmonella and Listeria, the process that cell-based meat must go under guarantees a sterile product, safe to consumption (Post et al., 2020).

Labeling cell-based meat is still a difficult task. In November 2022 in the Asia-Pacific region the word "cultured" has been approved. The EU as well as the United States have not concluded on how to differentiate animal-based meat from cell-based meat (Miyake et al., 2023). The first cell-based meat hamburger was made in 2013 by the CSO of Mosa MEAR, Professor Mark Post (Tuomisto, 2019). The first authorization for cultured meat was in Singapore, in December 2020 (Lähtenmäki-Uutela et al., 2021).

CONSUMER ACCEPTANCE

With The European Alliance aiming to make alternative food more accessible, many people are considering changing their diet to a plant-based one to safeguard biodiversity, animals' welfare, and human health. As studies show, the consumption of alternative foods is more common among women, adults, and people with higher education (Lehto et al., 2023).

According to a study conducted by Wendin & Nyberg (2021), consumer acceptance is highly influenced by familiarity as well as cultural settings. Red seaweeds, unlike other novel foods, are more easily accepted because of its minimal psychological barriers.

Consumers acceptance is troubling when we speak about insects consumption. Entomophagy (eating insects) is still uncommon in western societies and as long as it lacks acceptance it will be overlooked even if the food is safe and nutritious (Govorushko, 2019). One way to increase acceptance on entomophagy is by including insects in familiar products like flour, pasta, protein bars or burgers. Furthermore, we can provide information about their nutritional value and health benefits, as well as on the positive impact on environment sustainability (van Huis, 2021).

Regarding PBMs, for this industry to grow, broad consumer acceptance is needed. China registered a percentage of 95.6% of consumers accepting PBM, followed by India with 94.5% and the US with 74.7%. An increase in the consumption of plant-based meats has also been observed in the UK and in Australia (a study reported a five-fold increase over four years in PBM). In Europe, consumers are not only unfamiliar with plant-based animal products to a large extent, but also, those who know and consume this type of products, consider them much less sensory-appealing than the animal-based homologs. (Rubio et al., 2022). Nevertheless, a quarter of Finns are planning to reduce their consumption of beef and increase the consumption of plant protein in the next few years (Lehto et al., 2023).

A study made by Rolland et al. (2020) showed that the people informed about CBM were more easily led to acceptance than the people with poor knowledge about the topic. Therefore, one of the first measures that should

be adopted is educating the population about the benefits of CBM, i.e. climate impact, human health, animals' welfare. A study carried out in 2011 showed that the development of the plant-based meat industry would lead to a decrease in water consumption by 82-96%, greenhouse gas emissions by 78-96%, of the energy consumed by 45%. However, these predictions were disproved in 2015, in a study that showed that there will be a slight reduction in the carbon footprint, but not as dramatic as previously estimated (Rubio et al., 2020; Tumisto et al 2011; Mattick et al., 2015).

CONSUMER ACCEPTANCE IN ROMANIA

Since there are currently no studies or public reports at the national level about the grade of acceptance of the population regarding alternative foods and products from cellular agriculture, we conducted a survey from 18th of March 2023 to 30th of March 2023 on 229 participants of different ages and levels of education.

Figure 1 presents the 12 questions regarding alternative food and cellular agriculture, and its acceptance rate in Romania.

The study was conducted on a population included in three age groups, between 18-30 years, 30-50 years, and older than 50 years. Figures 2, 3 and 4 show the responses of the persons questioned regarding the intention to try CBM, to change the animal protein in the diet with an alternative one or to give up animal meat in the diet. The survey showed that, out of 110 respondents aged between 18-30 years old, only 22.7% of them would try CBM; this percentage is small, but still 6.3 times higher than the one resulting from the answers given by population over 50 years old (in this case the percentage was 3.6% for 56 persons). The percentages remain approximately the same for the question related to the intention to change the animal proteins in the diet with alternative ones. Surprisingly, 41.8% of the youngest group were willing to remove meat from their diet.

Following this survey, we can conclude that in Romania, the total percentage of people who want to switch to alternative foods is unsatisfactory, but it is slightly higher for the young generation, who are more inclined to

accept such a change. This lack of desire to try alternative foods or products from cellular agriculture, indicated by the extremely low percentages obtained in the survey, can be explained on one hand by the lack of information on what alternative food or cellular agriculture means, how they are obtained, what are their benefits on human health, animals and environment, and on the other hand it is due to cultural customs, Romania being a country where traditional cuisine is mainly based on meat.

1. What age category do you fall into?
 - 18-30 years old
 - 30-50 years old
 - > 50 years old
2. The last level of education
 - Primary school (4 grades)
 - Elementary school (8 grades)
 - Highschool
 - University or higher
3. How informed are you regarding alternative food (edu, veg, algae, insects, etc.)?
 - Very informed
 - In a moderate way
 - I am not informed
4. How often do you eat meat?
 - Daily
 - A few times a week
 - I don't eat meat
5. Did you know that around 35-37% of gas emissions come from the food industry?
 - Yes
 - No
6. Do you really find meat substitutes in the supermarket?
 - Yes
 - No
7. Would you try lab-grown meat?
 - Yes
 - No
8. Would you try lab-grown vegetables?
 - Yes
 - No
9. Would you try pizzas that contains flour made from insects?
 - Yes
 - No
10. Would you consider replacing protein from meat with protein from algae, insects, and others?
 - Yes
 - No
11. Would you give up meat in your diet for a sustainable future?
 - Yes
 - No
12. Did you know that insect-based foods are now available in stores?
 - Yes
 - No

Figure 1. The survey made in Romania from 18th of March 2023 to 30th of March 2023 on 229 participants

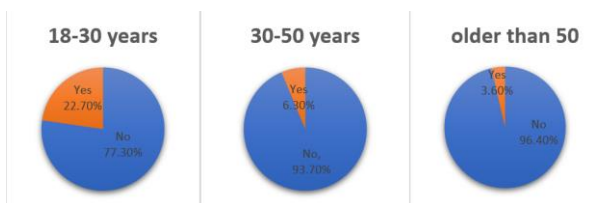


Figure 2. Willingness to try CBM in Romania

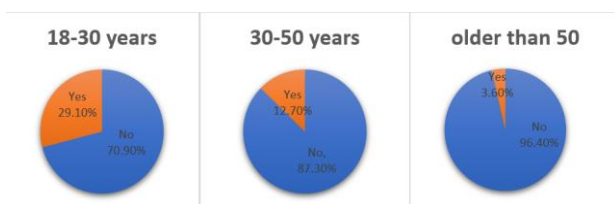


Figure 3. Willingness to change animal protein to alternative protein in Romania

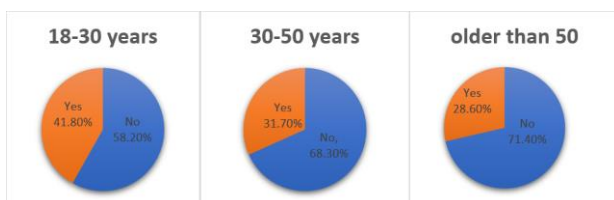


Figure 4. Willingness to remove meat from diet in Romania

CONCLUSIONS

Over the years there has been an increase in the use of water, energy, and land, as well as a

growth in GHG emissions due to the food industry, therefore alternative food and cellular agriculture represent a sustainable choice, especially in terms of products from meat.

Red seaweeds are a sustainable alternative protein, are easy to consume and contain essential nutrients. Being already used all around the globe, all the regulatory framework already exists, and it is well accepted by people, especially by Asian countries.

Soy protein is the most accepted alternative food with a wide variety of aliments like, soy-burgers, soy sausages, soy-salami and so on. With further development of its organoleptic properties, it should attract a larger number of people.

Insects as food have many sustainable benefits, such as reduced water consumption, less land area for growth and good protein conversion. However, their use as food will be more difficult to normalize due to consumer perception.

Cellular agriculture being a new field, it is not well received by consumers, and in addition, further development of the products is required in order to achieve the best product, with essential nutrients and organoleptic characteristics similar to animal – based meat.

In conclusion, for a sustainable future, we should dramatically change both the food industry and our perception in regard with the food. Currently there are mainly two extremes, people that don't receive enough food and people that waste too much of it. With alternative food we could balance this difference and learn how to use food in a mindful way so we could preserve our planet.

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THE IMPORTANCE OF GREEN AREAS FOR REDUCING NOISE POLLUTION IN THE URBAN ECOSYSTEMS – OPINION SURVEY

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Abstract

Important sources for environmental noise exposure are road, railway and air traffic, or building sites. Noise exposure can also occur through other sources such as wind turbines, and leisure activities such as listening to loud music or other audio content including participation in e-sports (video and computer game competitions). Excessive noise can cause annoyance; in addition, research shows it increases the risk for hypertension, sleep disturbance, hearing impairment, tinnitus and cognitive impairment, with increasing evidence for other health impacts such as adverse birth outcomes and mental health problems.

Today, noise pollution is a major environmental problem, cited as a top environmental risk to health across all age and social groups and an addition to the public health burden. Prolonged exposure to high levels of noise impairs human health and well-being, which is a growing concern. Traffic and other urban noises affect not only human well-being, but also disturb and endanger the survival of species crucial to the urban environment. The mental health benefits from natural sounds and general quietness are considered psychological ecosystem services provided by nature. Urban green space and vegetation produce positive psychological effects. Public parks, gardens and other small green areas provide pleasant sounds from nature, such as rustling leaves, swaying tree branches and chirping birds. Quiet urban areas offer acoustic relief to city inhabitants from noisy surroundings, a prerequisite for mental restoration and well-being.

In this paper, we present the results of the questionnaire for the survey of public opinion regarding the perception of the level of noise in the urban ecosystems. The questionnaire contains ten questions and was addressed to various social categories, of age and with different levels of education. The questionnaire, the statistical interpretation and the graphics were made with the help of Google forms.

Key words: *ecosystem services provided by nature, green area, noise pollution, urban environment.*

INTRODUCTION

Today, noise pollution is a major environmental problem, cited as a top environmental risk to health across all age and social groups and an addition to the public health burden. Prolonged exposure to high levels of noise impairs human health and well-being, which is a growing concern (Aletta et al, 2022).

Noise pollution comes from conventional sources, such as roads, railways, airports, and industry; however, high noise levels may also come from domestic or leisure activities. Traffic and other urban noises affect not only human well-being, but also disturb and

endanger the survival of species crucial to the urban environment.

The mental health benefits from natural sounds and general quietness are considered psychological ecosystem services provided by nature. Urban green space and vegetation produce positive psychological effects. Public parks, gardens and other small green areas provide pleasant sounds from nature, such as rustling leaves, swaying tree branches and chirping birds. Quiet urban areas offer acoustic relief to city inhabitants from noisy surroundings, a prerequisite for mental restoration and well-being (WHO, 2018).

In this paper, we present the results of the questionnaire for the survey of public opinion

regarding the perception of the level of noise in the urban ecosystems. The questionnaire contains ten questions and was addressed to various social categories, of age and with different levels of education. The questionnaire, the statistical interpretation and the graphics were made with the help of Google forms.

MATERIALS AND METHODS

Create the Google Drive form and questionnaire

Step 1

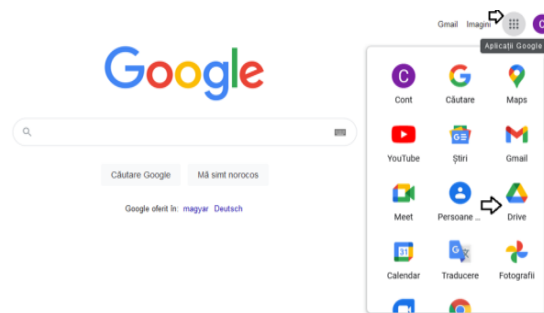
With the browser we created a Google user account, then we went to the G-mail page to create a new account using the "Create an account" option and entered all the necessary data to register and benefit from all Google services offered (Figure 1).

Step 2

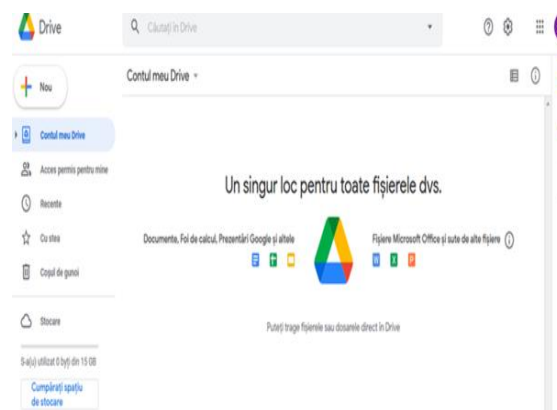
To enter Google Drive, we clicked the button called "Google Apps". After displaying its window, we clicked on the "New" button that offers the submenus: "File"; "Upload a file"; "Upload a file"; "Google Docs"; "Google Spreadsheets"; "Google Presentations"; "Google Forms"; "More". We accessed the "Google Forms" window and added the necessary information (Figures 2, 3, 4).

Step 3

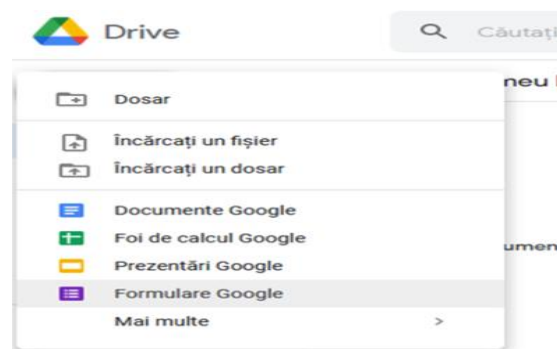
In this stage, we filled in the title of the topic in the column where it says "Untitled form", then we wrote the question and how many answer options we have. In the "Multiple answers" box we have several options on how we want to make the answers. To add more questions we have to press the button with the circled plus sign (Figures 5, 6).



Figures 2.



Figures 3.



Figures 4.

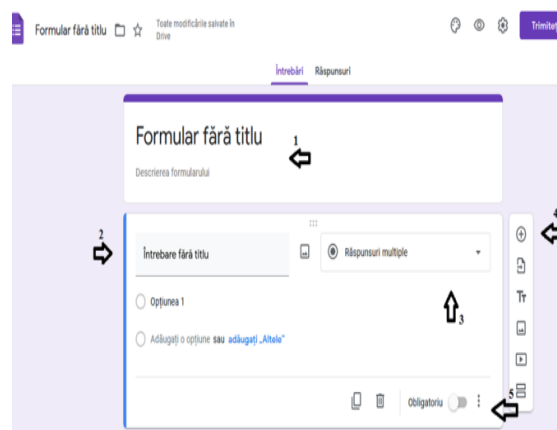


Figure 5.



Figures 1.

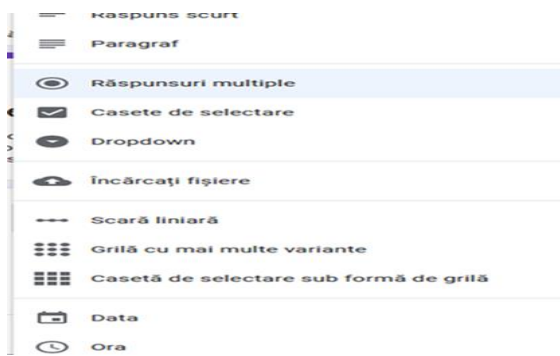


Figure 6.

Step 4

After completing the questionnaire, we can see what it looks like by clicking on the eye icon and if we see that everything is well written we can send it for completion by the general public. We have the option to send it by e-mail, on social networks or by creating a link. Finally, to see the number of people who completed the questionnaire, we must click on the Answers option (Figure 7).

Step 5

By accessing the Answers option, we see how many people answered the questionnaire and we have the option to see an overall summary drawn in a diagram or we can see how each person answered these questions (Figure 8).

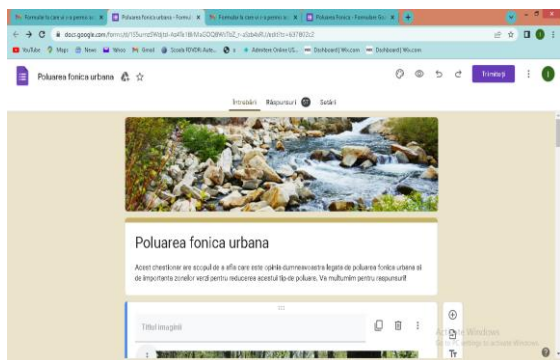


Figure 7.

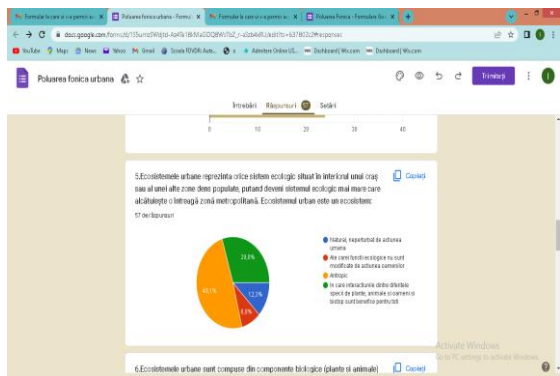


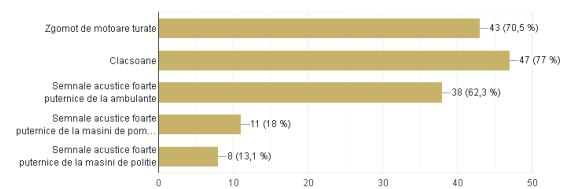
Figure 8.

RESULTS AND DISCUSSIONS

1. With what words can you associate the urban acoustic environment on boulevards and intersections?

- The sound of revving engines
- The horn
- Very loud acoustic signals from ambulances
- Very loud acoustic signals from fire engines
- Very loud acoustic signals from police cars

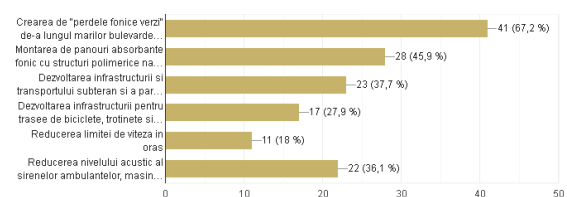
1. Cu ce cuvinte puteți asocia mediul acustic urban pe bulevarde și în intersecții?
61 de răspunsuri



2. What measures should be taken to reduce urban noise pollution?

- Creating "green sound curtains" along major boulevards by planting evergreen trees
- Installation of sound-absorbing panels with natural or synthetic polymer structures
- Development of the infrastructure and underground transport and the electric car fleet for the above-ground public transport
- Development of the infrastructure for bike paths and electric scooters
- Reducing the speed limit in the city
- Reducing the acoustic level of ambulance sirens, fire engines, police cars

2. Ce măsuri de reducere a poluării fonice urbane ar trebui luate?
61 de răspunsuri

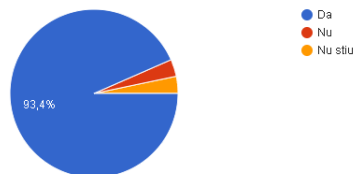


3. Do you consider that green areas are important for attenuation noise pollution in urban ecosystems?

- Yes
- No
- I don't know

3. Considerati ca zonele verzi sunt importante pentru atenuarea poluarii fonice in ecosistemele urbane?

61 de răspunsuri

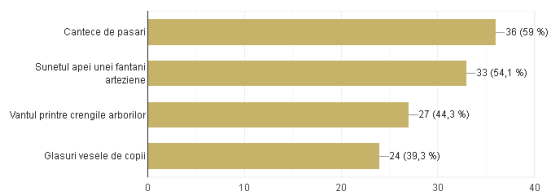


4. With what words can you associate the urban acoustic environment in green areas, parks, public gardens?

- Bird songs
- The sound of water from an artesian fountain
- The wind among the branches of the trees
- Joyful children's voices

4. Cu ce cuvinte puteti asocia mediul acustic urban din zonele verzi, parcuri, gradini publice?

61 de răspunsuri

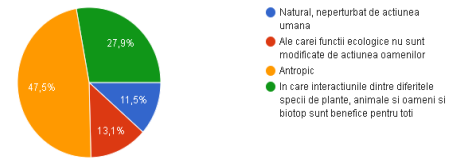


5. Urban ecosystems represent any ecological system located inside a city or another densely populated area, potentially becoming the larger ecological system that makes up an entire metropolitan area. The urban ecosystem is an ecosystem:

- Natural, undisturbed by human action
- Whose ecological functions are not modified by human action
- Anthropogenic
- In which the interactions between the different species of plants, animals and people and the biotope are beneficial for all

5. Ecosistemele urbane reprezinta orice sistem ecologic situat in interiorul unui oraș sau al unei alte zone dens populate, putand deveni sistemul ecologic mai mare care alcătuiește o întreagă zonă metropolitană. Ecosistemul urban este un ecosistem:

61 de răspunsuri

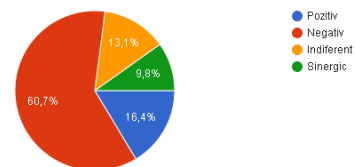


6. Urban ecosystems are composed of biological components (plants and animals) and physical components (soil, water, air, climate and topography). The biological complex also includes human populations, their demographic characteristics, their institutional structures, and the social and economic tools they use. The physical complex includes buildings, transport networks, modified surfaces (e.g. parking lots, roofs and landscaping) and environmental changes resulting from human decision-making. How do you consider the impact of the human population within the urban ecosystem compared to the other biotic and abiotic components?

- Positive
- Negative
- Indifferent
- Synergistically

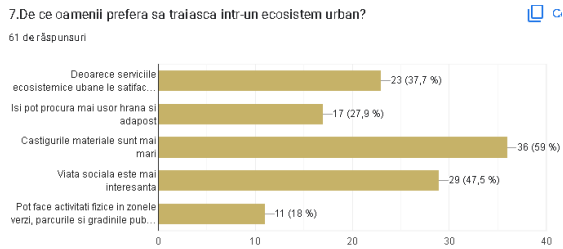
6. Ecosistemele urbane sunt compuse din componente biologice (plante si animale) și componente fizice (sol, apă, aer, climă și topografie). Complexul biologic include și populațiile umane, caracteristicile demografice ale acestora, structurile lor instituționale și instrumentele sociale și economice pe care le folosesc. Complexul fizic include clădiri, rețele de transport, suprafețe modificate (de exemplu, parcuri, acoperișuri și amenajări peisagistice) și modificările de mediu rezultate din luarea deciziilor umane. Cum considerați ca este impactul populației umane în cadrul ecosistemului urban față de celelalte componente biotice și abiotice?

61 de răspunsuri



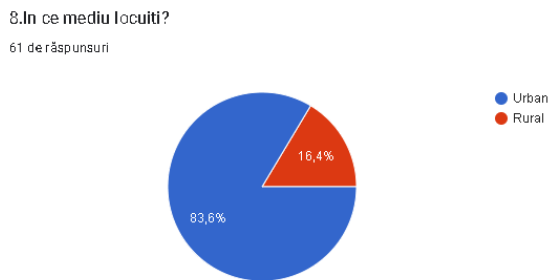
7. Why do people prefer to live in an urban ecosystem?

- Because urban ecosystem services satisfy their primary needs
- They can get food and shelter more easily
- The material gains are greater
- Social life is more interesting
- They can do physical activities in green areas, parks and public gardens



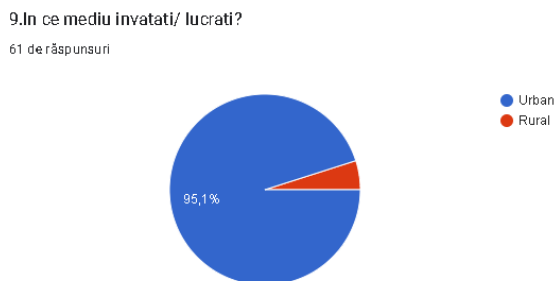
8. In what environment do you live?

- Urban
- Rural



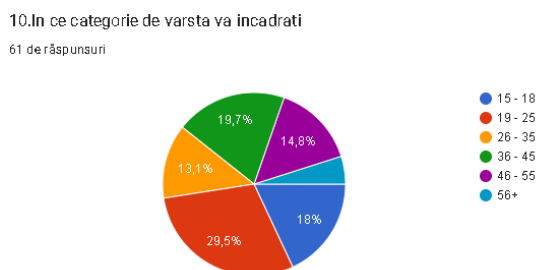
9. In what environment do you study/work?

- Urban
- Rural



10. What age category do you belong to?

- 15-18
- 19-25
- 26-35
- 36-45
- 46-55
- +56



CONCLUSIONS

From the answers provided by the 61 respondents to the questions of our questionnaire, we can draw the following conclusions:

- The vast majority of respondents live and study or work in the urban environment, some of them live in the rural environment, but study or work in the urban environment.
- The urban acoustic environment in congested areas (boulevards, intersections) mainly associates it with the noise of horns, the noise of revving engines and the very loud noise produced by ambulances.
- Among the noise protection measures for citizens proposed by us, they found the most interesting: "green sound curtains" obtained from evergreen trees along the boulevards and sound-absorbing panels with natural or synthetic polymer structures.
- Respondents associate the urban acoustic environment in green areas, parks and public gardens with cheerful, pleasant, soothing sounds.
- Only about 50% of the respondents consider that the urban ecosystem is anthropogenic, which shows us an erroneous perception due to a lack of knowledge of ecology.
- Regarding the impact of the human population on urban ecosystems, 61 of the respondents consider it negative, while 16% consider it positive, 13% indifferent and 10% synergistic.
- In the top of preferences when we asked why people prefer to live in an urban ecosystem, the answer was chosen: "The material gains are greater".
- Green areas are considered important by the respondents of our questionnaire for reducing the level of noise caused by heavy traffic in urban areas and for the possibility of being able to do sports and relax in nature.

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SECTION 02
SUSTAINABLE DEVELOPMENT OF
RURAL AREA

WHAT IS A PASSIVE HOUSE?

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Abstract

The present study aims to highlight the energy efficiency of the type of constructions named as "Passive Houses", comparing the energy efficiency of a house built in a conventional way with a house built according to the regulations imposed by the Passive House Institute, having as a reference a classic passive house and a premium passive house.

In the first part, the article presents generalities about what a passive house is and how it is built, what criteria should be followed and how such a project is certified, at the same time it is presented how a residential building is built, in a conventional manner, according to the legislation in force.

In the second part of the article, different systems and components that make up a passive house are shown, how they manage to increase the energy efficiency of a house compared to a conventionally built house, at the same time managing to reduce the carbon footprint and reducing the monthly bills for energy.

In the last part of the article, using graphs and tables, it is shown how the energy efficiency of a house is directly influenced by the chosen systems and their quality, how by respecting the criteria imposed by the Passive House Institute one can obtain a total or only partial improvement in the life quality of the living space, energy independence and at the same time a significant reduction in monthly energy payments.

Key words: carbon footprint, energy efficiency, passive house.

INTRODUCTION

Nowadays, a frequently debated topic is related to the high consumption of energy that affects biodiversity and accelerates the effects of climate change in an alarming way, as well as the energy crisis with a significant impact on the way to construct a building, or a house.

In the 20th century, different engineers, designers and researchers approached different ideas aimed at reducing the costs for heating and cooling a home and making it more energy efficient, some projects also address issues related to the environment or reducing the carbon footprint taking into account the type of materials, their origin and their implementation. The thermal efficiency of single-family homes built before 1989 (and many years after) is extremely low. The walls of the houses were generally made with GVP brick (with vertical voids) up to 37.5 cm thick and rarely with BCA at the same time the walls were uninsulated. The slabs of the houses, above ground, from the 0.00

level, and from the last level, under the bridge, were uninsulated.

At that time, in Romania, polystyrene was not used, as it was still a material that was not known to everyone, just like mineral or basalt wool, cellulosic insulation, etc. The joinery was made of solid wood, with two sashes, each with a 4 mm sheet of glass, fixed with putty. Thermal bridges and the lack of tightness of the houses were present almost everywhere, so the energy efficiency of the houses was poor.

New design regulations have appeared (for example: regulation no. 305/2011 of the European Parliament and the Council of Europe), through which member states have introduced provisions, requirements, regarding the safety of buildings and other constructions, health, durability, energy efficiency, environmental protection, economic aspects and other aspects of public interest importance.

The term "Passive House" has been debated for more than 20 years, but it is not clear to everyone what this term includes, on the contrary, the terms "Passive House", "ECO House", "Green

House" are often confused, "Energy efficient house", "nZEB House".



Figure 1. A modern passive house

- What do nZEB and NZEB mean? - these do not represent certifications, they are described at the national level as "near Zero Energy Building" and "Net Zero Energy Buildings", they produce the energy necessary to carry out activities at the local level from non-conventional sources.
- Eco, sustainable and green? - These are vague terms, everyone confuses a passive house with an Eco or Green one, thus the BREAM, LEED and LBC certifications were born.
- Energy independence - It represents the fact that the house will produce the necessary energy by itself, throughout the year. Not all passive houses have energy independence, because this also requires having an energy storage system, not being connected to the public grid.

"Passive houses" are defined as buildings that have an extremely low thermal energy demand; therefore they do not need active heating. Thus, the temperature of the house can be maintained "passively", only by using the existing internal heat sources and the solar energy entering through the windows, as well as by minimal heating of the incoming fresh air.

A passive house receives certification as a passive house when the energy requirement is less than 15 kWh/m²/year, for an energy efficient house it is necessary that the energy requirement does not exceed 45-50 kWh/m²/year, and a nZEB house has an energy consumption of less than 112 kWh/m²/year.

Myths related to building a passive house:

- Passive houses cannot be built from any material; false because only energy efficiency

matters. There are many materials recommended but not mandatory.

- A passive house has no windows; not only do they have windows but their placement and size significantly alter the efficiency of such a project.
- Certification can only be done for newly built houses; false, already built houses can also be certified, again, only the energy efficiency of the building is taken into account.
- There are many passive houses; a house is only truly passive if it is Passive House certified.
- The air is closed; if the air is closed it means that something is wrong in the house.
- You cannot open the windows; false, you can open the windows if you want, but it's not necessary.
- Only houses can be certified; false, certification can also be done for offices, schools, indoor swimming pools, etc.
- Passive houses are unesthetic; passive houses can have various shapes, often the simplest shapes are used to have an increased efficiency when it comes to the thermosystem and comfort in the home.

MATERIALS AND METHODS

The purpose of such a project combines comfort and at the same time brings a significant ratio when it comes to saving money, a passive house being much more energy efficient when it comes to heating, even up to 75% compared to a newly built house, at the same time, the electrical energy needed for living can even be up to 100% obtained from non-conventional sources.

Thermal insulation, sealing and controlled ventilation of the rooms add increased comfort to living, in some countries with a much more suitable climate for such a project, the houses no longer need a heating system, some projects abandoning the installation for heat, concentrating more much on the position in front of the sun, thermosystem and ventilation of the rooms. All this is possible only by following a well-defined set of principles.

The basic principles of Passive Houses are:

- Choosing a continuous thermosystem, reducing the thermal bridges between the materials used.

- High degree of air tightness, it has the role of not allowing the transfer of air between the interior and the exterior in an uncontrolled way.
- Choosing a ventilation system that aims to recover heat (HVAC),
- Choosing a quality window system.
- Choosing the exposure of the house so that you benefit from as much heat as possible from the sun.

Most of the certified passive houses in Europe are in Germany, Germany being the cornerstone of passive houses. The first passive house in the world was also built here, in 1988 in Kranichstein – Darmstadt Germany, and since then it has been operating at the same designed parameters.



Figure 2. The first passive house built in Germany

In Romania, the "Passive House" standard is quite difficult to achieve, the cost of putting it into operation being significantly higher than for a conventional house. However, there are completed projects, and some are ongoing. The first passive house construction in Romania was in the Burlusi - Arges locality (Figure 3. a), but the first certified passive house is EvoHouse"with 4 apartments, from a 45 m2 studio to a 110 m2 2-room apartment (Figure 3. b).



Figure 3. Examples of passive houses in Romania

Another example is Casa Buhnici, from Corbeanca, Ilfov (Figure 3. c).

RESULTS AND DISCUSSIONS

The goal of a passive house is: comfort and a significant ratio for saving money, energy efficiency even up to 75% compared to a newly built classic house for heating, and the electricity needed for living can even be up to 100% from non-conventional sources.

The thermal insulation, sealing and controlled ventilation of the rooms add increased comfort to living conditions, in some countries with a much more suitable climate for such a project, the houses no longer need a heating system, some projects abandoning the installation for heat, focusing more on the position with respect to the sun, the thermic system and the ventilation of the rooms.



Figure 4. Ventilation system with heat recovery (Photo source: INCD URBAN-INCERC)

The criteria for designing a passive house are:

- The heat requirement for heating must be a maximum of 15kWh/m²/year or the thermal load for heating of a maximum of 10W/m²
- Annual space cooling requirement maximum 15 kWh/m²/year
- Annual primary energy consumption of a maximum of 60 kWh/m²
- The air tightness must be high, n₅₀ ≤ 0.6 hourly shifts
- Frequency of the overheating period of maximum 10%

Classification and certification of passive houses:

- Classic Passive House (this type of house is the classic one)
- Passive House Plus (this type of house produces the energy it needs through non-conventional sources)
- Premium Passive House (this type of house produces more energy than it consumes, so what is produced in addition enters the network, the owner becoming a prosumer).



Figure 5. Heating pump water-soil



Figure 6. Ventilation system with heat recovery directly into the wall



Figure 7. Different types of solar panels (Photo source: INCND URBAN-INCERC)

Benefits of a passive house:

- The uniformity of temperatures is a great advantage when it comes to the comfort felt in the home, as there are no direct cold currents, it results in a much healthier and more welcoming environment, at the same time, throughout the life of the building, mold or moisture will not form behind the thermosystem or inside the home.
- Together with the reduction of electricity and energy for heating the rooms, our bills decrease, in the best case even close to 0.
- The building will withstand legislative changes and at the same time market changes, such a project is more difficult to devalue, all these will contribute to increased comfort, to a much healthier environment and at the same time, the project itself, contributes to the reduction of pollution and indirectly contributes to the reduction of the carbon footprint.

Disadvantages of a passive house:

- Such a project means an additional cost and at the same time a much more competent and specialized workforce, such a project does not take into account the water supply side, the carbon footprint of the materials, nor how they affect the environment.
- The documentation to authorize and certify such a project is much thicker and more difficult to do, at the same time,

and resistant to mechanical shocks of the outer and inner surfaces of the walls is less than in conventional buildings.

The energy balance is a laborious procedure that allows obtaining a real picture, at a given moment, of how the flows of energy carriers enter, are distributed, transformed and consumed inside the balance outline, highlighting the conversion efficiency of energy, size and type of losses for each of the analyzed points. The energy regime of each individual receiver, on each distribution board, up to the general electrical supply board is evaluated.

The energy balance is also a practical way of expressing the principle of energy conservation and highlights the equality between the energies entering and leaving the analyzed circuit for a certain period of time. The energies out of the balance sheet consist of the energies in any form usefully used and the energy losses.

Conventionally, it is considered useful energy, the energy used for: electrical and mechanical drives, steam generators, thermal processes, transport, electrical network elements, welding, lighting, etc.

The energy losses related to the technological process are considered the following: the sensible heat contained in the combustion gases, the heat lost by radiation and convection, the electrical energy lost by the Joule effect, the Corona effect, as well as the electromagnetic and mechanical losses of the engines, etc.

According to Romanian regulations, the energy balance is carried out with the help of a proprietary calculation program, but there is the possibility of using PHPP (Passivhaus Projektierung Paket), designed according to the European standard ISO 13790, which can be used successfully not only in the case of passive houses.

CONCLUSIONS

At the moment, the main effort regarding the implementation of renewable energy sources is focused on improving the technologies, to lower their costs.

It is especially desired to increase the performance of the equipment and reduce the energy consumed in operation, but also the judicious choice of processes, depending on the geographical conditions and the habits of future users.

The passive house is a certification standard based on measurements made on a building by an accredited institution.

The passive house requires compliance with 5 criteria, these being insulation, sealing, avoiding thermal bridges as much as possible, a ventilation system with heat recovery, the window system and the exposure of the building.

Passive House represents a certification that only considers energy efficiency.

More and more people want a life as comfortable as possible, free of expenses and worries, the projects related to energy efficiency, more precisely passive house projects have made everyone think, all those who want to build in 2023 a house also consider this possibility.

However, such a project requires more extensive documentation and a specialist to handle all the necessary.

Even if not all projects are certified as passive houses, there is still the possibility that the projects only meet some criteria, thus reducing monthly expenses.

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USING NATURE AS A SUSTAINABLE SOLUTION FOR RESIDENTIAL COMPLEX DESIGN

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Abstract

People will always need a home. Statistically speaking, the next 50 years will be drier than the last 50 years, so society must change its way of building houses. At this moment, most of the houses are built with poor-quality materials, the insulation is of poor quality. Water is used as if it were single-use, and the soil around the house is not used for food but cement is poured over it. This paper presents a model of a residential complex in Romania, that is following the goals of sustainable development. Considering the economic, social, and environmental aspects, the residential complex will lead to the improvement of the quality of life of the people who will live there, the creation of new jobs, and the improvement of the quality of the environment.

Key words: house, quality, sustainable development, water.

INTRODUCTION

The construction of houses has a significant impact on climate change in several ways. The use of energy and materials in construction, as well as the operation and maintenance of buildings, are responsible for a significant portion of greenhouse gas emissions. According to United Nations, CO₂ emissions caused by the construction industry hit a new high (Kennard et al., 2022).

Man-made environment accounts for approximately 40% of global CO₂ emissions from fuel combustion and 25% of global greenhouse (GHG) emissions. (Tony et al., 2021). Cement production is one of the most polluting industries, accounting for 7% of global CO₂ emissions (Reiter, 2022).

Achieving a net-zero carbon emissions scenario by 2050 will necessitate a swift transition towards low-carbon alternatives in the cement and concrete industry. McKinsey hosted an interactive panel at the World Economic Forum Annual Meeting 2023 (AM23) in Davos, Switzerland, to discuss the future of the industry (Heincke et al., 2023). It is feasible to achieve decarbonization in the cement and concrete sector by leveraging a combination of strategies as well as reducing the amount of clinker in cement, using newer technologies such as kiln electrification, storing or utilizing the remaining CO₂ emissions. However, these

solutions are quite new and have not yet been deployed at scale. Until these solutions will be implemented, it is necessary to find new ways to build houses and minimize the environmental impact.

To conserve the resources for the future generation, it is important to use for the construction of new houses local materials like timber, bricks or clay, and also to combine all the solutions that exist in the matter of energy-efficient, renewable energy, reusing water, and even using the greenhouse for food and tea.

MATERIALS AND METHODS

This article introduces a blueprint of a residential community located in Romania, Buftea. To find the optimal solutions, it is important to know the specific environmental conditions of the area.

Buftea is a city in the Ilfov County, in the southern part of Romania, located approximately 20 km northwest of Bucharest. The climate in this city is classified as humid subtropical climate according to the Köppen-Geiger climate classification. This means that the summers are hot and humid, while the winters are relatively mild with occasional snowfalls. The average temperature is 11.1°C, with a mean maximum temperature of 23.8°C in July, and a mean minimum temperature of -3.7°C in January. Buftea receives an average of

633.3 mm of precipitation per year, with the wettest month being June and the driest month being February. The vegetation in Buftea is characterized by mixed forest, consisting of deciduous trees such as oak, beech, and hornbeam, as well as coniferous trees such as pine and spruce (China, 1997).

Considering the climatic conditions in the mentioned city, the suitable materials for building a sustainable house in this city can be timber, rammed earth, and hempcrete. For all those materials there are some advantages and disadvantages that require to be mentioned.

Timber is wood that has been prepared for use in construction or carpentry. It refers to the harvested trees that have been sawn into planks or boards and processed for various applications, such as building structures, furniture, and paper products. Hardwood species such as mahogany, ash, or oak require 60 years, and in some cases up to 100 years to reach maturity. Conversely, softwood species, such as larch, pine, and spruce, require around 25 to 30 years to reach maturity.

As deforestation is a concern, it is crucial to ensure the replenishment of timber sources through the planting of new trees. (Bitesize, 2020). Timber is one of the small numbers of materials that have multiple advantages, like being safe to handle, and not leaking chemical vapors into the building (Ramage et al., 2017). It is also known for its durability, versatility, and aesthetic appeal. Compared with traditional buildings made from concrete and steel that are expected to produce around 2,000 metric tons of CO₂ emissions, trees absorb carbon from the atmosphere and a part of that carbon remains stored within the tree's woody biomass even once the tree is transformed into timber building material. Also, mass timber is proven to be earthquake-resistant, and prefabricated timber homes can withstand natural disasters, as well as floods, and category 4 hurricanes. Timber construction can create jobs and boosts the economy by encouraging the use of locally sourced, bringing benefits to local economies (Burrell, 2023).

While timber has many advantages as a building material, it also has some disadvantages, including fire hazards. Timber is highly flammable, and in case of fire, it can easily spread and cause damage to the building.

Timber has also the susceptibility to insects and rot, as well as fungal decay (Davies, 2021). It requires regular maintenance such as staining or painting to protect it from the elements and to prevent decay and insect infestations. There are limited availability disadvantages. The supply of quality timber can be limited, also the production of timber can have negative environmental impacts such as deforestation, soil erosion, and habitat destruction (Folk, 2020).

Another eco-friendly building material is rammed earth.

Rammed earth is an ancient building technique that has been used for thousands of years. In fact, archaeological evidence suggests that rammed earth was used in the Fertile Crescent region as early as the 9th-7th millennium BC (Leick, 1988). This ancient technique offers a sustainable method to build a resistant house. This technique requires the compaction of a moist mixture of soil that has suitable proportions of clay, gravel, and stabilizer (Miller, 2020). This mixture is laid up directly into a freestanding wall (Easton, 2007).

Rammed Earth buildings are an excellent choice for energy retention, it provides excellent insulating options. During colder months retain heat inside the structure to prevent extreme interior temperature changes (Miller, 2020). Besides high thermal mass and insulation properties, durability and resistance to fire, low embodied energy, and carbon footprint, as the material is locally sourced and minimally processed are important benefits. In rammed earth walls it is possible to enhance additional recycled materials, such as metal or glass, which can provide structural reinforcement and aesthetic interest (Easton, 2007).

Using rammed earth as a construction material has some disadvantages like limited availability of skilled labour and specialized equipment for construction, susceptibility to moisture damage, and requiring careful design and maintenance (Rammed Earth Buildings: Code and Safety Issues, 2015).

Hempcrete is a natural building material, a bio-composite material made from the woody inner fibers of the hemp plant, a renewable resource. It is also used for insulation, roof insulation and to create walls (Mango et al., 2019).

The advantages of hempcrete are high thermal mass and insulation properties, providing natural temperature control and energy efficiency, and low embodied energy and carbon footprint, as the material is locally sourced, minimally processed, and has low maintenance requirements (Maggio and Marrocchino, 2019). Hempcrete exhibits inherent pest resistance, rendering it a safe and environmentally sustainable building material. Its freedom from any form of pesticides and fungicides obviates concerns about health risks to children and pets. In contrast to wood, Hempcrete is also immune to the hazards of termite infestation (Agbanlog, 2023).

In terms of disadvantages, hempcrete is a relatively new material with limited research available on its performance as a building material. Many construction companies that have started to use hempcrete have had access to it for only a few years, and there is a need to relearn old knowledge about creating a hemp building. This lack of experience can make it challenging to find a construction company that specializes in hempcrete use. Engineering experts have identified that hempcrete has a high capacity for handling moisture, which can be advantageous in some cases but also limits its range of uses. Hempcrete may not be suitable for marine or underground works due to its potential for moisture-related issues. Additionally, hempcrete may not be suitable for use in extremely warm climates with a high degree of moisture, as it could lead to increased heat inside the building (Lynch, 2020).

Efficient heating and cooling systems are essential for reducing energy consumption and minimizing greenhouse gas emissions. Various types of systems can be used for heating and cooling, including:

Heat pumps: A heat pump is a device that transfers heat from one place to another using electricity, for example, a heat pump can transfer geothermal energy stored in the ground from the ground in the house. Heat pumps are an efficient solution that can provide significant cost savings and protection from energy price fluctuations over their lifetime. In comparison to gas boilers, heat pumps can offer lower energy costs for households and businesses that utilize them. This is due to their ability to transfer heat from one place to another, rather

than generating heat by burning fuel like gas boilers (IEA, 2022).

Radiant heating: Radiant heating systems deliver heat to a building's floor, wall, or ceiling panels. The system relies on radiant heat transfer, where the heat moves directly from a hot surface to the objects and people in the room via infrared radiation. This process is akin to the heat felt from a hot stove element across the room. When located in the floor, radiant heating is referred to as radiant floor heating or floor heating. Radiant heating offers several advantages. It is more efficient than baseboard heating and usually more efficient than forced-air heating since it eliminates the energy losses inherent in duct systems. For people with allergies, radiant heat may be preferred since it does not circulate allergens as forced air systems can. Hydronic systems, which rely on liquid heat transfer, require relatively low electricity consumption (The United States Department of Energy, 2023).

Unglazed Solar Collectors: An unglazed solar collector is a type of solar thermal technology that is simple in design. A heat-absorbing material, usually made of dark metal or plastic, captures solar energy and transfers it to a fluid that flows through or behind the absorbing surface. This process is similar to how a garden hose exposed to sunlight can warm the water inside it.

Since unglazed solar collectors lack a glass cover or "glazing" on the collector box to retain heat, they are described as "unglazed." This design choice results in a trade-off. On one hand, unglazed solar collectors are simple and cost-effective, but on the other hand, they lose heat back to the environment and typically operate at lower temperatures. As a result, unglazed collectors are most effective for smaller heating applications or in conjunction with traditional heating systems, where they can preheat air or water and reduce the need for fossil fuels (EPA, 2022).

Green roofs, also known as 'vegetated roofs' or 'living roofs. They consist of a waterproofing membrane, a layer of soil as a growing medium, and vegetation, which are installed over a traditional roof. These roofs are typically ballasted to provide the necessary weight and stability to support the added weight of the growing medium and vegetation. Green roofs

offer numerous benefits, including environmental, social, economic, and aesthetic advantages. They can help to reduce energy consumption, improve air and water quality, mitigate stormwater runoff, provide habitat for wildlife, and enhance the aesthetics of buildings and urban areas. In addition, green roofs can also contribute to the overall sustainability of a building or development, as they can reduce the urban heat island effect, increase biodiversity, and provide opportunities for community engagement and education (GSA, 2021).

One major disadvantage is the high cost of installation and maintenance. The initial installation cost can be up to two or three times the cost of a traditional roof, and ongoing maintenance costs are also higher due to the need for regular watering, fertilization, and pruning. These costs can make green roofs prohibitive for many building owners, especially those on a tight budget. Another disadvantage is the potential for leaks and water damage. While green roofs are designed to be waterproof, there is always the risk of leaks and damage to the underlying roofing system. If not properly installed and maintained, green roofs can lead to costly repairs and even structural damage to the building.

In addition, green roofs can be heavy and may require additional structural support to be added to the building. This can add to the initial installation cost, as well as potentially limit the types of buildings that can support a green roof (Gorski, 2023).

There are different types of green roofs, such as extensive green roofs, that are characterized by a thin layer of growing medium and are designed to support low-growing, hardy plants such as sedums, grasses, and herbs. They are lightweight and require minimal maintenance, making them ideal for retrofitting existing buildings or installing them on new buildings with limited structural capacity (Life on Roofs, 2023).

Intensive green roofs that consist of deeper substrates. This type offers the opportunity to design more complicated and elaborate gardens.

The London Plan, published by the Mayor of London in March 2016, defines brown roofs as:

‘Roofs which have a layer of soil or other material which provides a habitat or growing medium for plants or wildlife.’

Approximately 65% of water usage in a household is attributed to activities such as showering, bathing, handwashing, and laundering clothes. As a result, greywater is generated from these activities. Greywater can be recycled easily and at a low cost, treated, and repurposed for applications such as toilet flushing and irrigation (Interwa, 2023).

Blackwater is the term used to describe wastewater that originates from toilets and bathrooms, containing human waste and urine. Additionally, kitchen water and dishwasher discharge are also classified as blackwater due to their contamination with grease and disease-causing microorganisms (Your Home, 2013).

Constructed wetlands are man-made systems designed to replicate the natural processes of wetlands. These systems are constructed by engineers and scientists and are used for water treatment by filtering pollutants from water that flows through them. Wetland vegetation, soils, and microbial communities play a crucial role in the natural filtration process, and the same principles are used in constructed wetlands to improve water quality. Constructed wetlands use a combination of physical, chemical, and biological processes to remove pollutants from the water. The result is a sustainable and cost-effective method for improving water quality that can be used in various applications, such as wastewater treatment, stormwater management, and agricultural runoff treatment (Muthukumaran, 2022).

Anaerobic digestion is a process of treating blackwater that is both energy-efficient and capable of recovering valuable energy and nutrients from the wastewater (Slompo et al., 2019)

The membrane filtration process is a technique based on physical separation that allows for the isolation of molecules with distinct sizes and characteristics. This process is governed by the pressure gradient that exists between the two sides of a specialized membrane, which allows for the selective passage of certain molecules while retaining others. Membrane filtration is a widely used method due to its ability to separate components with high precision, efficiency, and selectivity. It has numerous

applications in various fields, such as wastewater treatment, food and beverage processing, pharmaceutical production, and desalination. The effectiveness of the process is determined by the properties of the membrane and the operating conditions, such as the pressure and the flow rate (AlfaLaval, 2022).

RESULTS AND DISCUSSIONS

Based on the solutions that best suit the chosen area, Buftea, Romania, and following research, the model of a residential complex that follows the goals of sustainable development can look in the following way.

The residential complex is composed of ten houses on the ground floor, with a size between 70-100 square meters. With a concrete foundation because the average precipitation in this city is 633.3 mm per year. This value would not affect a rammed earth foundation, but considering that the water drainage system will be based on constructed wetlands, that will bring more moisture to the soil. This choice is for a strong resistance of the houses. Walls would be built using the technique that was used in the past first houses, rammed earth. This method is a suitable choice for retaining energy by providing optimal insulation.

Using a brown roof is an optimal solution to moderate the heat island effect, also it provides shade, removes heat from the air and reduces temperatures of the surface by around 5-10 C° and also the surrounding air. Installing this kind of roof is a way to save money because it is not necessary to plant any vegetation, the surface is left to self-vegetate from windblown and bird seed dispersal. When a house is built, the aim is to give back to nature what was taken.

Home insulation can be improved with hempcrete. This bio-composite can be used as an insulating material. Timber can be used as an external shade for windows, in this way the house can be cooled sustainably.

With the purpose to implement solutions with a lower carbon footprint, Unglazed Solar Collectors can be a suitable solution for warm water.

Water reuse is the most important thing to do at this time. By using natural processes, constructed wetlands offer a promising alternative for treating polluted water sustainably and effectively. This solution can

be designed to fit different landscapes, climates, and water sources, allowing for a customized approach that adapts to local conditions and needs.

This system can be installed all along the residential complex, behind the houses. All the pipes that conduct grey water from the house are going directly to a constructed wetland. After completing the purification route through the system, the water is accumulated in a basin. Here there are two possibilities for using water. The water can be used for irrigation or the washing machine, or it can be ultra-filtered with the help of membrane station technology and can be used as drinking water.

Regarding the recycling of black water, there is required a septic tank and four basins, the septic tank is where the solid material will settle. Biogas can also be produced here, which can be used in the network of the residential complex. From the septic tank, the water will pass through a pipe system into the next basin, which is called the anaerobic basin, where the sludge will be digested faster. From here the water passes into the next three basins where the environment changes completely. From an anaerobic environment, the water will reach a basin full of aquatic flora and fauna. Then, the water is purified and collected in a basin and can be used for irrigation and the toilet basin.

The residential complex is arranged in a circular shape. In the middle, there will be a greenhouse that will provide the necessary vegetables for the residents. By building this greenhouse, it will be possible to create new jobs, also it will improve the quality of life.

CONCLUSIONS

In conclusion, the residential complex proposed in the paper has the potential to improve the quality of life of the people who will live there, create new jobs, and improve the quality of the environment. By using sustainable and environmentally friendly solutions such as rammed earth walls, brown roofs, hempcrete insulation, and constructed wetlands for water treatment and reuse, the complex aims to reduce its environmental impact and promote a healthier and more sustainable way of living.

Water is a precious resource, and the proposed water management system of the residential complex offers a sustainable and effective

solution to this issue. Constructed wetlands, coupled with ultra-filtration membrane technology, provide a cost-effective and eco-friendly way of treating polluted water, which can then be used for irrigation and as drinking water. The recycling of black water through a septic tank and basin system further improves water conservation.

Furthermore, the proposed circular arrangement of the complex with a central greenhouse can also create new job opportunities and provide fresh vegetables for the residents. The use of renewable energy sources such as solar collectors and biogas production can also contribute to the economic sustainability of the complex.

The residential complex model presented in the paper aligns with the principles of sustainable development and can provide a viable alternative to traditional housing solutions, leading to a more balanced and sustainable way of life for its residents.

Overall, the sustainable residential complex model proposed for Buftea, Romania showcases the feasibility and benefits of implementing sustainable housing solutions and highlights the importance of sustainable living in modern times.

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SECTION 03
WATER RESOURCES MANAGEMENT

PUMPING INSTALLATIONS FOR WASTEWATER SYSTEM REHABILITATION IN BĂBENI TOWN

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Abstract

In this paper, the behaviour of the pumping stations in the town of Băbeni, Vâlcea county, is evaluated in relation to the sewage system and wastewater treatment. They are an important factor that has environmental effect, which needs to be managed carefully, also improving city inhabitant life quality. Their high energy consumption must be reduced, being an element of secondary environmental impact, the networks safety is one of the key efficiency standards, expressed in a quality-like approach, this criterion must be enhanced by quantitative factors. The pumping installation introduction for wastewater system rehabilitation is an extraordinary solution resolving practical issues, even is not a current approach.

Key words: pumping stations, sewage system rehabilitation, waste water.

INTRODUCTION

Sewerage systems are, in the modern era, indispensable to a locality, they represent a basic condition for ensuring population life quality and for environmental protection (Ionescu, 2010).

Like any other construction, once built the sewage systems are subject to aging or face under-dimensioning caused by the development of the localities served, so they will undergo rehabilitation, modernization, expansion works during their lifetime (Iancu, 2021).

And this is the situation of the sewage system in the town of Băbeni, a town in Vâlcea County, located approximately 20 km south of the county seat, Râmnicu Vâlcea Municipality, and 30 km north of Drăgășani Municipality, on the right side of the Olt River, approximately 2 km from it.

Vâlcea County is located in southwest Romania (Oltenia), bordering Alba and Sibiu counties to the north, Hunedoara and Gorj to the west, Dolj to the south, Argeș and Olt to the east; includes 2 municipalities, 9 cities and 78 communes, with a total population of 413,570, with an area of 5,765 km², representing 2.41% of the country's area (INS, 2023).

The summary conditions description of the area shows that the first snowfall generally occurs in the last days of November, the snow phenomenon is recorded around 50 days/year, the prevailing winds are from the north (14.8%), frost is present (110-120) days/year, the frost depth characteristic of the studied area is (0.60-0.70) m (STAS 6054-77, 1977).

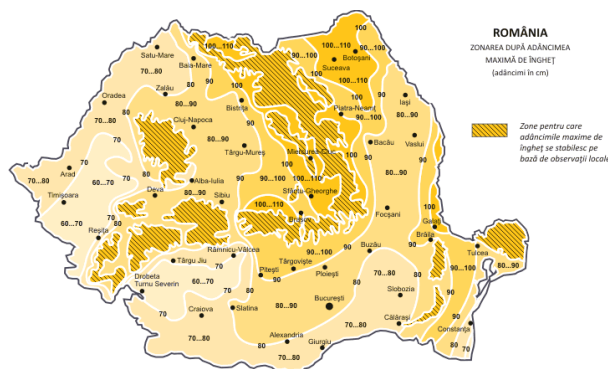


Figure 1. Zoning according to the maximum frost depth of the territory of Romania (STAS 6054-77)

According to NP 100-1/2013 and SR 11100/1-1993, regarding the zoning of the territory of Romania in terms of peak values of ground acceleration for design, for earthquakes with the average recurrence interval (IMR) 100 years, the entire location falls within the area

with $ag = 0.20g$, and the corner period is $T_c = 0.70$ s.

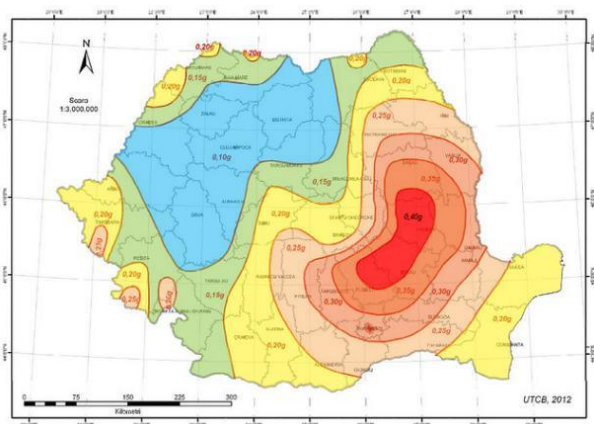


Figure 2. Zoning of the peak values of the ground acceleration for the design of ag on the territory of Romania (SR 11100/1-1993)

In the existing situation in Băbeni, the sewerage works without pumping, the section collecting domestic wastewater and conducting it to the treatment plant passes through several private properties.

It is proposed to place a sewage pumping station, in the lowest part of the neighborhood, for the correct functioning of the area of blocks in the city of Băbeni.

MATERIALS AND METHODS

The water requirement is determined according to specification of STAS 1343-1/2006, as in Table 1.

Table 1. Specific water flow values for household needs (qg) and coefficient of daily non-uniformity values (STAS 1343-1/2006)

Areas or localities differentiated according to the degree of equipment with cold, hot water and sewage installations	qg(i)	Kzi(i)
Areas with households having internal installations of cold water, hot water and sewage, with individual preparation of hot water	100-120	1,20

For the main parameters for sizing water requirements, the following aspects were taken into account:

- Population evolution in the next 20 years;
- Specific residential and non-residential water flows;
- Hourly and daily coefficients of variation;
- Coefficients for covering water losses;
- Water for fire extinguish;

- flow rates for the dimensioning and control of the elements in the water supply system (sources, treatment station, intake pipe and distribution network).

For the sizing of sewerage systems, the maximum hourly used flow from the use of water by type of consumption (household, public, economic agents, etc.) is considered (NP 133/2-2013).

The relationships used to determine the water requirement are:

$$Q_{zi, med} = \frac{1}{1000} \cdot \sum_{k=1}^n \left[\sum_{i=1}^m N(i) \cdot q_s(i) \right] \quad [m^3/zi] \quad (1)$$

$$Q_{zi, max} = \frac{1}{1000} \cdot \sum_{k=1}^n \left[\sum_{i=1}^m N(i) \cdot q_s(i) \cdot K_{zi}(i) \right] \quad (2)$$

$$Q_{or, max} = \frac{1}{1000} \cdot \frac{1}{24} \cdot \sum_{k=1}^n \left[\sum_{i=1}^m N(i) \cdot q_s(i) \cdot K_{zi}(i) \cdot K_{or}(i) \right] \quad (3)$$

where:

$N(i)$ - number of users;

$q_s(i)$ - specific flow (average daily amount of water needed by a consumer);

$K_{zi}(i)$ - coefficient of daily variation;

$K_{or}(i)$ - coefficient of hourly variation.

To calculate the water requirement (STAS 1343-1/2006) the relationship used is:

$$Q_s = K_s \cdot K_p \cdot Q \quad (4)$$

where:

K_p - coefficient representing the addition of water quantities to cover water losses in the water supply system up to the users' connections; for rehabilitated distribution networks $K_p = 1.35$;

K_s - servitude coefficient for covering the own needs of the water supply system (for washing tanks, washing the distribution network, etc); $K_s = 1.05$.

All the elements of the water supply scheme, from the intake to the treatment station, will be dimensioned at the QIC flow rate (STAS 1343-1/2006):

$$Q_{IC} = K_p \cdot K_s \cdot Q_{zi, max} + K_p \cdot K_s \cdot Q_{Ri} \quad (5)$$

where:

K_p - coefficient of increase in water demand

K_s - servitude coefficient

Q_{Ri} - the recovery rate of the intangible fire reserve

The water treatment plant components are dimensioned to the same QIC.

Between the treatment station and the storage tank, all components (intake, pumping stations) are dimensioned to:

$$Q_{IC} = \frac{Q_{IC}}{K_s} \quad (6)$$

where:

QIC - dimensioned with equation (5)

Ks - servitude coefficient

For the dimensioning of the intake pipes, the specific flow rate for household needs was chosen considering the degree of equipment with cold water, hot water and sewage installations the values are: $q_s = 120$ l/person, day, when $K_{zi} = 1.30$.

RESULTS AND DISCUSSIONS

For the sewage system pumping station the calculation flow is:

$$Q_{or,max} = 6 \frac{l}{s} = 21,6 \frac{m^3}{h}$$

The caisson, in which the wastewater pumping station is located, is sized considering a storage time of approx. 5 minutes (12 starts/stops/hour):

$$V_{inmag,nec} = Q_{or,max} \cdot \frac{5}{60} = 21,6 \frac{m^3}{h} \cdot \frac{5}{60} = 1,8m^3$$

If the caisson diameter is chosen $D = 2.00$ m, the useful storage height will be:

$$H_u = \frac{V_{inmag,nec}}{\pi \cdot R^2} = \frac{1,8m^3}{\pi \cdot 2^2 m^2} = 0,57m \approx 0,6m$$

The caisson depth results:

$$H_{caisson} = H_{geod} + H_u + 0,4m$$

where:

H_{geod} - geodetic height of the caisson;

H_u - useful storage height (previously determined);

0,40 m - consists of: 0.20 m (guard height for the required volume) + 0.20 m (measured from the caisson scraper to the pump suction point).

Thus,

$$H_{geod} = CT - CR = 205,38mdMN - 202,82mdMN = 2,56m \approx 2,6m$$

where:

CT - land geodetic elevation

CR - surveyor's geodetic elevation

Deci,

$$H_{caisson} = 2,56 + 0,6 + 0,4 = 3,56m$$

The resulting pumping head (STAS 12594-1987) is:

$$H_{pump} = H_{geod} + H_u + 0,4 + H_r,$$

knowing:

$$H_{geod} = CR_{exit} - CR_{entry} = 208,83mdMN - 202,82mdMN = 6,01m$$

where:

CR_{exit} - exit point radier elevation

CR_{entry} - entry point radier elevation

H_r - pressure loss on the discharge pipe

knowing for a discharge pipe of $De = 110$ mm, having $L = 307$ m and $Q = 6$ l/s, $v = 0,74$ m/s, $hr = 5,4m/km$, local head loss - 15% (Kiselev, 1988), results:

$$H_r = 0,307km \cdot 5,4 \frac{m}{km} \cdot 15\% = 1,9m$$

In this manner:

$$H_{pump} = H_{geod} + H_u + 0,4 + H_r = 6,01 + 0,6 + 0,4 + 1,9 = 8,91m \approx 9m$$

Summing up, choose (1+1) pumps with the characteristics:

$$Q_p = 6 \frac{l}{s} = 21,6 \frac{m^3}{h},$$

$$H_p = 9m,$$

$$P = 4kW,$$

and the dimensioned caisson will have the dimensions $D = 2$ m, $H = 3,6$ m

The materials used for the sewer pipes in the rehabilitated portion will be PVC-KG SN 8, with diameters of Dn 250, Dn 400, respectively PAFSIN in the case of Dn 500, distributed as follows:

Table 2. Sewer system rehabilitation pipelines

Street	L (m)	Material	D mm
Calea lui Traian	2.015	PAFSIN	600
Dragoş Vrânceanu	548	PVC	250
Blocks area	509	PVC	250
Total			

The values obtained following the appropriate methodology, indicated by design standards and norms, are the basis for the sizing of the works required for the rehabilitation of the sewerage system.

CONCLUSIONS

The locality existing sewage system worked without pumping, by gravity. The section that led the waste water to the treatment plant was found to be in a bad condition that requires several interventions, and the fact that it is not located in the public domain creates difficulties. Therefore, in order to fix these problems and overcome the repair restrictions, it is proposed to place a sewage pumping station that will discharge into the extensive sewerage network.

In the waste water sewage system, the highest energy consumption is caused by pumping activity; the present paper aims, through the technical solutions presented, to lead to a

minimal environmental impact generated by energy consumption. The calculation methods used and the pumping installations choice rise to maximum energy performances, therefore complying with the condition of low impact.

ACKNOWLEDGEMENTS

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WATER SAFETY PLANNING AS AN EFFECTIVE MEANS OF ENSURING SAFETY OF A DRINKING-WATER SUPPLY SYSTEM

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Abstract

Effective planning for the supply of safe drinking-water must consider the growing uncertainties associated with a changing climate. Strengthening resilience can support water suppliers to better anticipate, respond to, cope with, recover quickly from, and adapt to, future shocks and stresses associated with climate variability and change. Water safety planning offers a systematic approach to build resilience to current and emerging climate threats by considering the implications of climate variability and change at each stage of the water supply.

In Romania, through the Order no. 2.721/2.551/2.727/2022, regarding the approval of the General Framework for water safety plans (WSP), the responsibilities of competent authorities and water producers and/or distributors regarding the preparation, assessment and approval of water safety plans, have been established.

The obligation to draw up the WSP rests with the producer, in collaboration with the water distributor, depending on the case, the implementation of such a document will be carried out by the water producer/distributor with the support of the WSP team, established at the level of water operators who supply at least 1,000 mc of water/day or supply a community with minimum 5,000 inhabitants.

Key words: *climate variability and change, water producer/distributor, Water Safety Plan.*

INTRODUCTION

The first World Health Organization (WHO) publication dealing specifically with drinking-water quality was published in 1958 as International Standards for Drinking Water.

In 1984-85, the 1st edition of the WHO Guidelines for Drinking-Water Quality (GDWQ) was published. It was recommended in 1995 that the GDWQ undergo a rolling revision process. During the revision of the WHO Guidelines for Drinking-water Quality leading to the 3rd edition, the value of the Water Safety Plan (WSP) approach has repeatedly been highlighted. The potential for water safety plan application has been evaluated in a series of expert review meetings in Berlin (2000), Adelaide (2001) and Loughborough (2001).

“The most effective means of consistently ensuring the safety of a drinking-water supply is through the use of a comprehensive risk assessment and risk management approach that

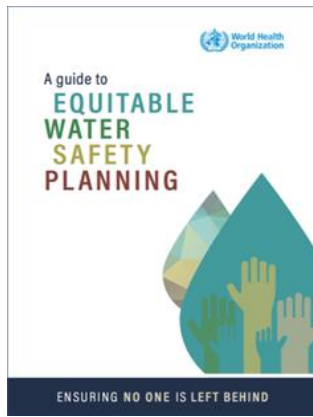
encompasses all steps in water supply from catchment to consumer. In these Guidelines, such approaches are called Water Safety Plans (WSPs)”.

The words above open Chapter 4 of the 3rd edition of the WHO GDWQ (2004) and capture the philosophy of the WSP approach.

The chapter describes the principles of the WSP approach rather than being a guide to their practical application.

This is why in 2009 it was published the “Water Safety Plan Manual, Step by Step Risk Management for Drinking Water Suppliers” by the joint effort of WHO and International Water Association (IWA). The aim of this Manual was to provide that practical guidance to facilitate WSP development focusing particularly on organized water supplies managed by a water utility or similar entity.

In 2023 it was published the Second edition of the manual.



As of 2017, WSPs have been developed and implemented in 93 countries worldwide (WHO & IWA 2017).

Kumpel et al. (2018) investigated the effectiveness of WSP implemented in 99 water supply utilities in 12 countries from the Asia-Pacific region. This study identified both benefits from WSPs and challenges in their implementation, including financial constraints and insufficient capacity.

Gunnarsdóttir et al. (2012) investigated the benefits of WSPs and critically analyzed the requirements for successful implementation and operation in Iceland, one of the first countries to adopt systematic preventive management for drinking water safety. The results showed several benefits of the WSP implementation process including changing the attitude of the staff to water safety and the culture within utilities. The lack of documentation and lack of regular internal and external audits were key obstacles to implementation of the WSP. The most important elements of success were the intensive training of staff and participation of staff in the whole process.

MATERIALS AND METHODS

In Romania, through the Order no. 2.721/2.551/2.727/2022, regarding the approval of the General Framework for water safety plans (WSP), the responsibilities of competent authorities and water producers and/or distributors regarding the preparation, assessment and approval of water safety plans, have been established.

The obligation to draw up the WSP rests with the producer, in collaboration with the water distributor, depending on the case, the

implementation of such a document will be carried out by the water producer/distributor with the support of the WSP team, established at the level of water operators who supply at least 1,000 mc of water/day or supply a community with minimum 5,000 inhabitants.

In order to produce a plan, a thorough assessment of the water supply process from water source to the consumer's tap must be carried out by the water provider.

Hazards and risk should be identified, and appropriate steps towards minimizing these risks are then investigated.

Stakeholders' communication and cooperation is vital for the success of WSP's implementation.

The development and implementation of WSP approach for each drinking water supply is as follows:

- Set up a team and decide a methodology by which a WSP will be developed
- Identify all the hazards and hazardous events that can affect the safety of water supply from the catchment, through treatment and distribution to the consumers' point of use
- Assess the risk presented by each hazard and hazardous event
- Consider if controls or barriers are in place for each significant risk and if these are effective
- Validate the effectiveness of controls and barriers Implement an improvement plan where necessary
- Demonstrate that the system is consistently safe
- Regularly review the hazards, risks and controls
- Keep accurate records for transparency and justification of outcomes.

Water safety planning is a systematic process that is widely recognized as the most reliable way to manage drinking-water supplies for the protection of public health.

Effective implementation of water safety planning can help to ensure that users receive safe and acceptable drinking-water in sufficient quantity. It achieves this by (see Figure 1):

- understanding the complete water supply;
- identifying where and how problems could arise;

- focusing initially on the priority risks, and putting barriers and management systems in place to proactively manage these risks;
- ensuring that all parts of the system continue to work effectively; and
- actively involving all stakeholders concerned with the supply of safe drinking-water.

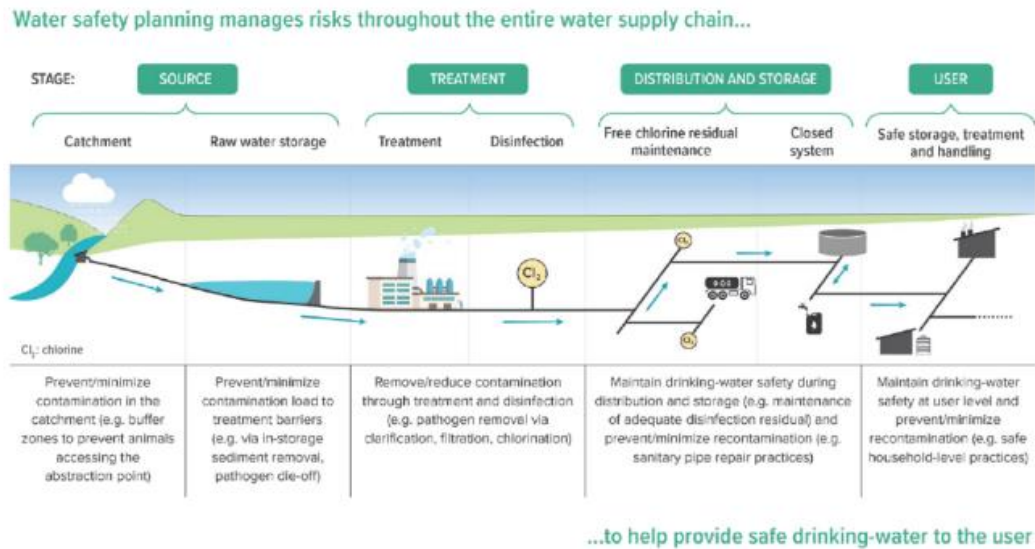


Figure 1. Stages of a Water Safety Plan

There is no single model approach for a water supplier to develop and implement water safety proper planning.

However, practical application of WSPs globally has identified several practices that underpin successful water safety planning, which should be considered by WSP teams.

Water safety planning is a continuous and iterative process for making stepwise improvements in the management of drinking-water supplies.

Water safety planning occurs in four phases (see Figure 2):

- **WSP development:** The WSP is established, and all 10 modules are developed and documented in the WSP.
- **WSP operation:** The WSP is applied routinely – that is, in activities that are conducted daily, weekly, and so on.
- **WSP verification:** WSP verification programmes take place.
- **WSP review:** The entire WSP is periodically reviewed. It is updated if needed (e.g., after an incident, a significant change in the water supply

or an audit). This review leads back to the WSP development phase.

Critical to success is ensuring that the WSP is a living document that is embedded within routine water supply management and is continuously reviewed and progressively strengthened.

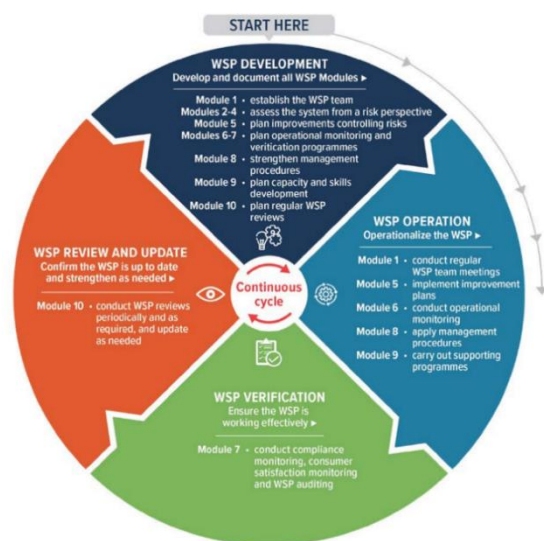


Figure 2. Stages of a Water Safety Plan

RESULTS AND DISCUSSIONS

Pilot Study for the Water Safety Plan for Ploiesti Water Supply

As part of an EU project, implemented between 2008 – 2009, a Water Safety Plan was drafted for the municipality of Ploiesti, which was recommended as a site with a number of unique challenges:

- It has a complex management system including several key stakeholders.
- The water supply is run by a private company Apa Nova.
- It has a complex water supply from three groundwater field wells and two surface water sources.
- The surface water is treated by a separate branch of National Administration Romania Waters (ANAR).
- It has suffered from oil pollution on a number of occasions with oil refineries within the catchment.
- It is a manageable area and close to Bucharest.
- Apa Nova is accredited with ISO 9001 and 14001. Apa Nova is a French company which has experience in applying the WSP concept.

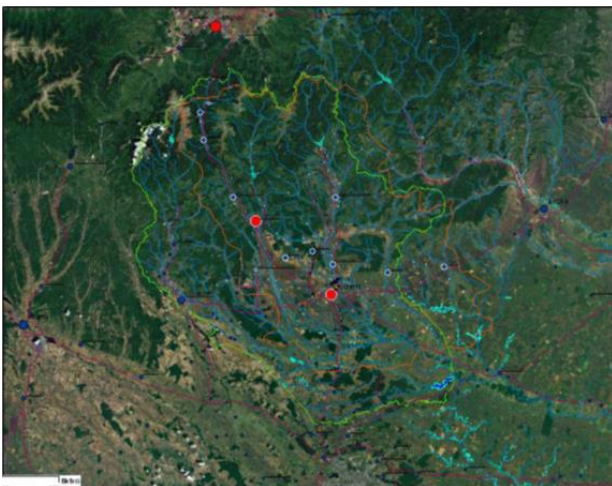


Figure 3. GIS Prahova County – water intakes

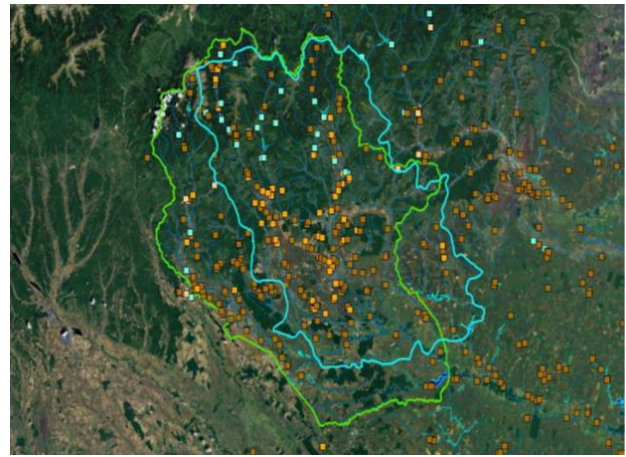


Figure 4. Water supply sources

This pilot study has covered the concepts of designing a WSP and provided eight tables showing the main items that need to be included in the WSP.

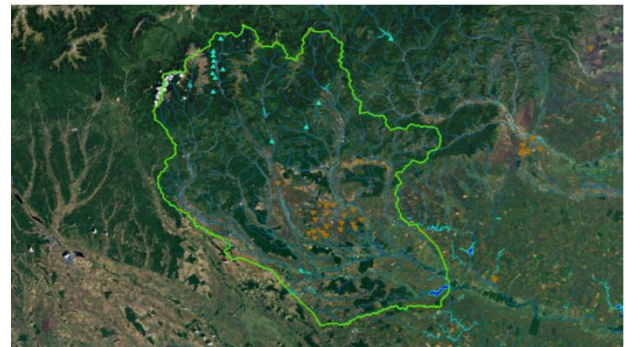


Figure 5. The National Administration Romanian Waters (ANAR) – Water intakes from surface and groundwater sources

As the WSP is a controlled document it has to be signed and authorised by the team. To improve the flexibility of the WSP, each table can be authorised separately and then combined in the final document.

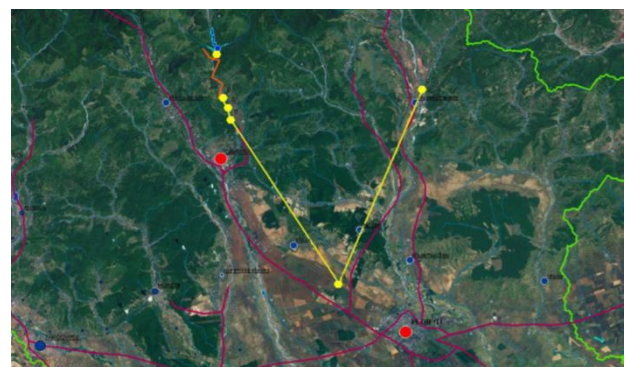


Figure 6. Water Supply System for Ploiesti



Figure 7. Deep groundwater front – monitoring points Apa Nova (GPS)

All WSPs should be derived by a dedicated WSP team of experts all conversant with the Ploiesti water supply.

Within the limited scope of the project it was impossible to establish such a team, as the members need to be appointed by senior management and apportioned time and resources to be established.

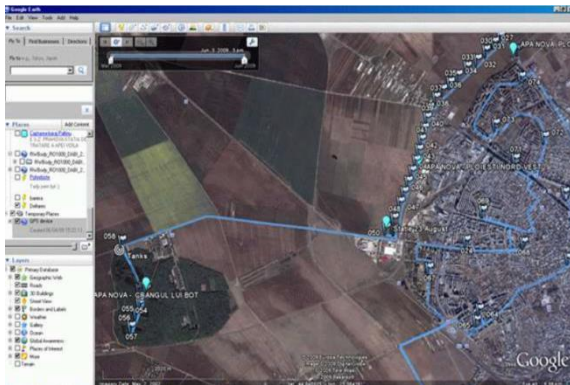


Figure 8. GPS Data for the waterwells and monitoring points Apa Nova

Therefore, the approach was to obtain as much data as possible, derive a template of the WSP, with suggestions on how this could be incorporated into the formal WSP, and to recommend how it should be further developed. Data and information were collected as follows:

- Nomination of the representatives of representative institutions for the Technical Working Group for WSP (the names and positions of the nominated persons, with responsibilities in monitoring and protecting the water source, were communicated).
- Specifications of the Treatment with Chemicals & Materials used together with the Quality Control procedures.

- Known dangers or threats to the safety of water quality in the pilot area, the reception basin, the treatment plant and the distribution systems.
- An audit plan/schedule compliance, including monitored parameters, monitoring frequency, analysis methods used, as well as quality control procedures
- List of historically contaminated sites in the pilot area.
- The documented list of measures (corrective actions or resistance to these threats), with any information that could be helpful.
- Records of any previous pollution incident in the pilot area.
- Water source protection programs
- Early warning and emergency procedures following a water pollution incident.
- Registration and preservation of procedures.
- Operating manuals (including preventive maintenance, as well as calibration equipment for measurement equipment).
- Training programs and relevant records for all staff (just one example would be useful at this stage).
- Laboratory manuals (including calibration procedures)
- The policy of customer complaints and the necessary procedures for resolving them
- Supporting ongoing programs, such as public awareness to protect water sources

CONCLUSIONS

One of the main advantages of drawing up a WSP is that any problem/gap in the protection and safety of the water supply should be highlighted.

A number of gaps were identified:

- Apa Nova is not the owner of the land on which the northeast catchment front is located, so it is difficult for the land to be fenced and the protection zone to be imposed. This legal contradiction must be resolved.
- The oil pipeline in the area of the raw water source from Lake Paltinu and Voila belonged to an oil company that apparently stopped working. Therefore, the issue of ownership and liability of the oil pipeline must be resolved, as currently the pipeline may continue to deteriorate due to lack of maintenance, posing an ongoing and increasing danger to the water

treatment plant. For this reason, once the property issue is resolved, it would be preferable to remove the pipeline.

- Apa Nova does not have a bacteriological laboratory, so the samples for the analysis of E. coli and total coliforms are sent to the Public Health Laboratory in Bucharest.

- A series of boreholes from the Crângul lui Bot catchment front indicate contamination with nitrates, in high concentrations. However, the data are insufficient to process the trend analysis, that is, to determine whether the nitrate concentration is increasing or decreasing over time.

ACKNOWLEDGEMENTS

This article represents the activity of documentation regarding the topic, the authors intend to continue research and draft a WSP for another water supply system for an urban or rural area in Romania.

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SECTION 04
CADASTRE

THE USE OF UAV AND GNSS TECHNOLOGY FOR THE PERFORMANCE OF SYSTEMATIC REGISTRATION WORKS

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Abstract

Systematic cadastre represents the registration in the land register of all buildings that belong to a TAU. In order for the field part to have a shorter duration and greater efficiency, it was chosen to make a flight with the WingtraOne GEN II drone, which represents one of the best performing drones, for better precision when georeferencing the images they used in the field "ground control points" for which the coordinates were determined with the help of GPS. AutoCAD and Agisoft programs were used to process the data obtained from the field, later vectorisation and identification of small problems appeared on the orthophoto plan. These works were carried out for the registration of buildings in the integrated cadastre and land register system.

The purpose of this work consisted in the acquisition of data for the realization of the systematic cadastre for a very large number of existing buildings in the localities that are part of the TAU Giroc. This was also marked by the difficulty of taking the data from the field and processing them, due to the high degree of coverage in the inside of the urbane area with buildings and vegetation.

Key words: Agisoft, AutoCAD, drone, GNSS, GPS, systematic cadastre

INTRODUCTION

Systematic registration represents "the process by which the real situation of all buildings located on the territory of Romania is translated into a unified computer system, with the aim of effectively managing the information regarding them" (Popescu, 2015).

The procedure and stages of the systematic registration works are provided in the Regulation of reception and registration in the cadastre and land register records (Order 600/2023) based on Law number 7/1996 on the cadastre and real estate advertising and the Regulation of July 9, 2014 on approval, reception and storage in the cadastre records and functional book.

The information regarding the buildings on the territory of Romania, which is translated into the IT system, is of a legal, economic and technical nature.

The economic information is determined based on the technical elements of the real estate, with the aim of establishing a real tax value for it.

The legal information has in mind "the identification of the owners/possessors of all buildings, as well as the registration in the land register of property rights and/or other real rights, based on the translative or constitutive acts of rights" (Popescu et al., 2015).

The process regarding the systematic registration is carried out at the level of the villages, by cadastral sectors.

In order to carry out systematic cadastre works and to collect the necessary data from the field, it is necessary to use modern technologies with high precision, such as Global Navigation Satellite System (GNSS) and unmanned aerial vehicle (UAV) (Popescu et al., 2020).

Taking data from the field with these technologies is done in an optimal time and on fairly large surfaces.

MATERIALS AND METHODS

The Trimble R8 GNSS receiver and the WingtraOne GEN II drone were used to perform the work.

The Trimble R8 GNSS receiver offers the necessary features and benefits in a single flexible and scalable system so that we can build a system perfectly adapted to ongoing projects (Figure 1). As requirements change, the Trimble R8 can be further configured to significantly increase field productivity, featuring 72 channels and 440-channel Trimble Maxwell™ 6 chips.



Figure 1: GNSS Trimble R8 receiver
(<https://ts-geosystems.com/product/trimble-r8-rtk-gps/>)

The GPS measurements were performed using the kinematic method.

The kinematic method RTK (Real-Time Kinematic position) implies the movement of a receiver during the observation period, while a receiver remains fixed on the known point.

The principle of positioning by the kinematic method is based on the fact that, first of all, a few points with known coordinates are occupied on which data is collected from satellites (it is necessary that the number of visible satellites be as high as possible) during a few minutes. Through this method, the vector between the stationary receiver (base) and the mobile one (rover) is established, with a precision of the order of two to three centimeters.

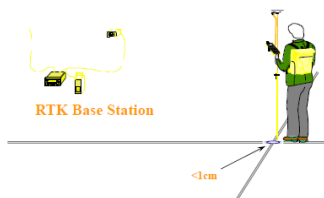


Figure 2. Kinematic method RTK
(Guidelines for RTK/RTN GNSS Surveying)

The reference receiver transmits its phase and code measurements to the mobile receiver. The biggest advantage is that it measures points without them being visible to each other (Figure 2).

Using RTK, the position can be determined in a few seconds with centimeter precision at a

distance of up to 50 km from the reference station.

Determining the coordinates using RTK takes a few seconds, as long as there is a radio link with the reference station, and an optimal opening to the sky.

Due to its ease of use, versatility, centimetres accuracy and reliability, RTK has become the standard for surveyors.

Complex works are processed at the office with specialized software.

WingtraOne GEN II drone (Figure 3) which has the advantage of: flying at 16 m/s (36 mph) for up to 59 minutes per flight for high coverage, at the same time WingtraOne can fly higher than drones limited to 20MP cameras so it can capture more field and more detail with each shot and a larger area per flight, high-quality optics mean it can reliably reconstruct the map even with smaller overlays, the system offers a safe and efficient mapping from constant altitudes even in the most mountainous areas, thanks to global field models or your own custom elevation data.

With WingtraOne data acquisition is much faster than with other tools, even for large areas. Can collect data up to 2x faster than other fixed wing drones and up to 8x faster than multicopter drones. (<https://www.dronezone.ro/>).

Thanks to years of continuous improvements, the WingtraOne drone consistently delivers high-resolution and accurate data, featuring GSD up to 0.7 cm/px (0.3 in/px) and absolute horizontal accuracy up to 1 cm (0.4 inches).



Figure 3: WingtraOne GEN II drone
(<https://www.es2-inc.com/uas-mapping>)

Mission Planner (Figure 4) was used to perform the flight mission, which represents a ground control station for the plane, helicopter and rover. It is only compatible with Windows. The mission planner can be used as a configuration utility or as a dynamic control add-on for the autonomous vehicle. Mission Planer is useful

for Monitor the status of your vehicle during operation: record telemetry logs that contain much more information than on-board autopilot logs, view and analyze telemetry logs and operate the vehicle in FPV (first person view).



Figure 4. Interface presentation of Mission Planner (<https://ardupilot.org/planner/>)

Agisoft software (Figure 5) was used to process the images, they represent a state-of-the-art software solution, with photogrammetry based on the central part of the software engine designed to the absolute limits, while the entire system is designed to generate specific results for this field which is based on automatic learning techniques for post-processing and analysis tasks (<https://roexpertcad.ro/services/mapare-geografica/>).

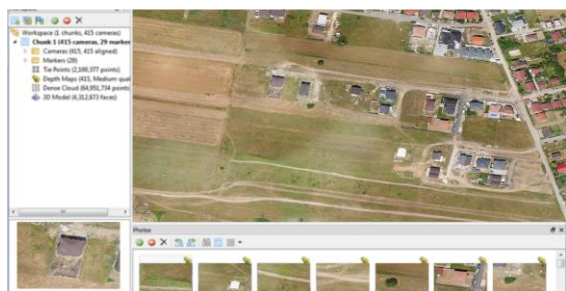


Figure 5: Agisoft software

The software enables the processing of images from RGB or multispectral cameras, including multi-camera systems, in dense point clouds, textured polygonal models, real georeferenced orthomosaics and DSM/DTM. Additional post-processing allows the removal of shadows and texture artifacts, the calculation of vegetation indices and the extraction of information for action maps of agricultural equipment, the automatic classification of dense point clouds, etc.

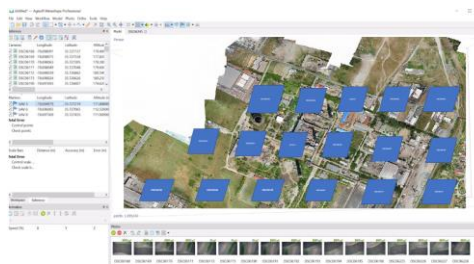


Figure 6: How to process images in Agisoft

Based on the last generation technology developed by Agisoft, Metashape (Figure 6) allows very fast processing, while providing very precise results for both aerial and close-up photography (up to 3 cm for aerial photography and up to 1 mm for the approach).

RESULTS AND DISCUSSIONS

In order to be able to start the systematic cadastre works within the Giroc TAU, it was necessary in the first stage to collect data from the field. This stage was carried out by marking the control points on the ground, in order to be able to align the images obtained in the 1970 Stereographic projection, in order to process the data in the AutoCAD computer environment. Terrestrial landmarks were materialized on the ground with the help of targets visible from the air. They were represented with neon orange color, to be easily visible on the ground, at the time of data processing.

The landmarks were placed in free areas, with high visibility in areas where constructions and vegetation did not represent an impediment to viewing the landmarks from the air.

The equidistance between the landmarks was 300 m.

The markings were placed and anchored as best as possible during the measurements in order not to introduce errors.



Figure 7. Marking control points on the ground

In this situation, 16 ground control points were used, as can be seen in figure 8.



Figure 8: Marker positioning mode

After the control points were materialized in the field, the coordinates of each point were determined by the GNSS method, stationing on each point, until the GPS receiver made all the corrections.

The planning of the flight mission was carried out, the stage in which the area and the flight route are entered in the drone's operating system. The software integrated into the drone system is Mission Planner, it comes bundled with all the drone's equipment, thus facilitating the entire process of photographing the studied area.

In the flight planning software, the operator defined the flight area, and drew up the plan that included the flight route with return positions. Depending on the planning parameters, the flight speed of the drone, the altitude of the flight, as well as the angle of the camera for the photography operation were calculated.

After accepting all the parameters, the drone started the flight mission respecting the selected area, from the initial take-off point.

The operator checks the entire process from the drone's console for added safety in accomplishing the mission.

At the end of the flight, in the office stage, the images from the drone were downloaded and the coordinates obtained with the GPS were processed in Stereo 70 coordinates.

Thus, the second stage was represented by downloading the coordinates of the control points on the ground and the representation in AutoCAD, as can be seen in figure 9.

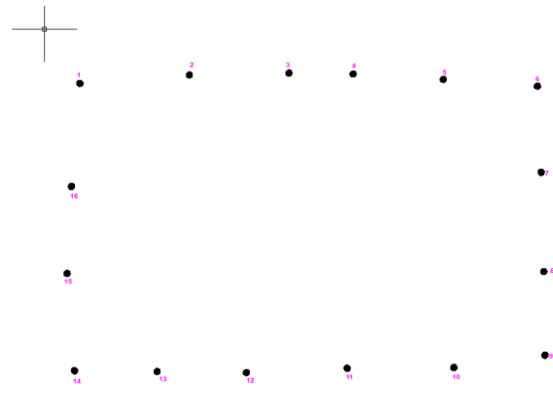


Figure 9: Representation in AutoCAD of control points

The next stage consisted in processing the images and obtaining the mosaic of images with the help of the Agisoft program, steps for this stage were represented by:

After georeferencing the images, a cloud of points was created at different levels (Low, Medium, High, Highest).

The next step was georeferencing the images and creating the orthomosaic using this field model and the resulting photographs.

As a finished product, the orthophoto plan of the area of interest resulted, the orthophoto plan being exposed at High resolution level (Figure 10), this being followed by the vectorisation process that was carried out in AutoCAD.

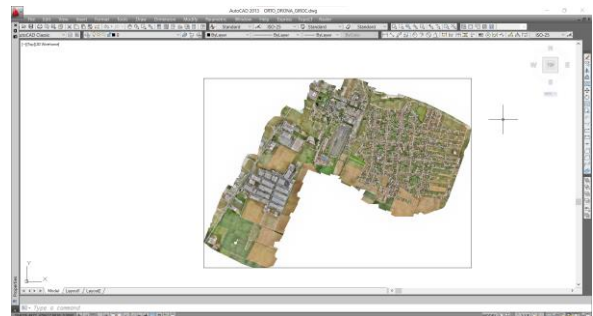


Figure 10. The orthophoto plan of the area of interest

After a more careful analysis of the orthophoto plan, it was found that there is a relative percentage of deformations of the images (Figure 11). The "aesthetic" problems appeared precisely because of this reason (interpolation of images on certain areas).

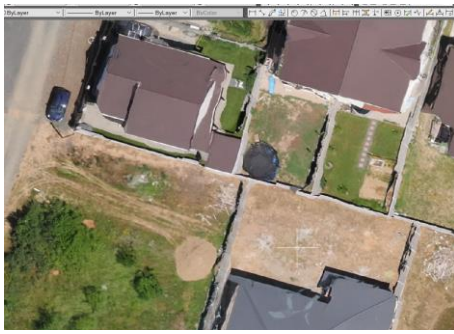


Figure 11: Exemple of „corrugation” of fences

When performing the photo interpretation and vectorisation of the orthophoto plan, the graphic database made available by the Timis Real Estate Cadastre and Publicity Office was also used as an extra help (Figure 12).

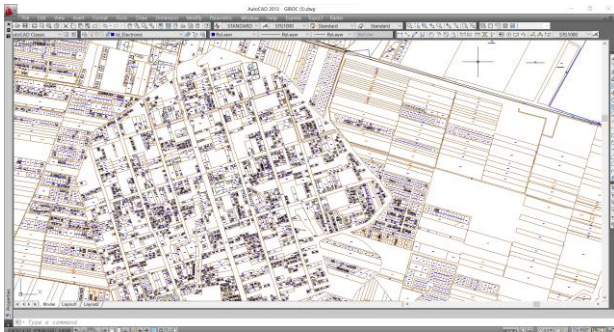


Figure 12. Graphic database

The two elements being overlaid, as can be seen in figure 13, were helpful in the vectorisation process of the constructions that did not have a graphic database.

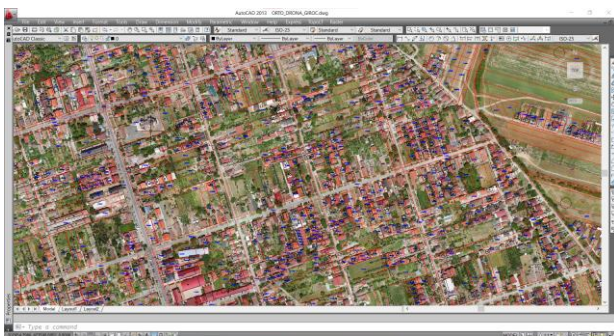


Figure 13. Overlayered of the graphic base over the orthophoto plan

For vectorisation, the points from the base, represented by the fence/post, were chosen, the stage represented in Figure 14, so if we had a slightly inclined fence, it represented an advantage to the operator, being able to establish more quickly the correct point that he must vectored.



Figure 14: Elaboration of the vectorisation of the orthophoto plan

For the vectorisation of a building, the operator looked for the posts and the direction between the posts that defined the outline of the building, even if the fence seemed to be wavy on certain portions (Figure 15).

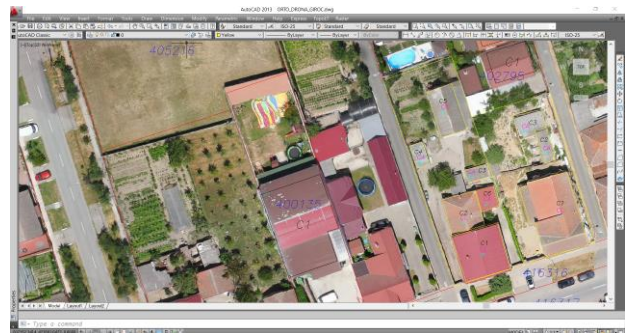


Figure 15. The vectorisation process of real estate

Also in this process, the identification of buildings without a database was also carried out, identifying the category of use and the height regime.

For the vectorisation of the buildings, the edge of the roofs according to Figure 16 was not used, but a minimum distance of 10-20 cm was kept from the edge, so that the wavy edge did not negatively influence the precision of the orthophoto plan and the vectorisation.



Figure 16: Model for realizing the vectorisation of constructions

These obtained materials provided effective help for obtaining the materials that led to the realization of: the measurement base for: Systematic Cadastre and/or General Cadastre. In order to achieve this stage, more time and attention was needed, the greatest attention being allocated to overlaying contours, a situation that can be seen in figure 17.

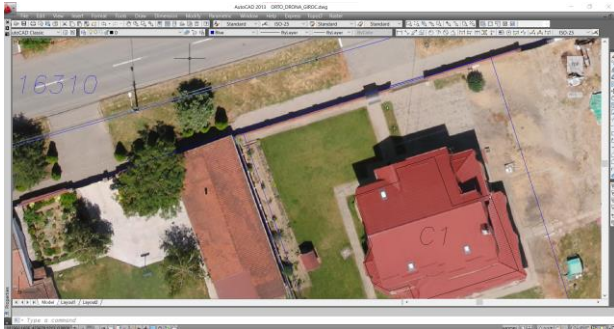


Figure 17. Real estate contour overlay

This operation was carried out on cadastral sectors (Figure18).



Figure 18. Vectorized cadastral sector

CONCLUSIONS

These works were necessary for the systematic registration of buildings within the radius of the Giroc TAU. The work presenting a real challenge due to the surface area of approximately 5200 ha and the large number of buildings that are in a continuous expansion, Giroc representing one of the largest TAUs in Timis county, this being the main reason why it was used UAV technology in collecting data from the field but also identifying certain elements from the field that could not be observed and it was difficult to access. The main

advantage of using this technology was the shortening of the time for the field stage, thus reducing the number of work force that would have been necessary for the terrestrial measurements, also reducing the related costs. Also, this method presents the problem of errors appeared during data processing, which lead to the loss of precision during vectorisation, for this reason interventions in the field are also necessary to be able to eliminate the errors. The most difficult and meticulous part of this work was represented by the office stage, which required a lot of work time in the vectorisation process, because the orthophoto plan presented certain deformation errors of property limits and buildings.

In conclusion, we can say that working with the drone offers, in addition to the identification of details in the field, an update of the orthophoto plan through detailed aerial images of the targeted area.

The need to prepare these types of works also arising from the identification of those details that were not included in the legal documents presented by the beneficiaries.

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MAPPING FEATURES WITH FIELD MAPS: A FAST AND ACCURATE SOLUTION FOR SPATIAL DATA MANAGEMENT OF THE CAMPUS AGRONOMIE HERĂSTRĂU

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Abstract

Geographic Information Systems (GIS) and Field Maps are powerful tools for the management and mapping of various types of geographic data. In this study, we explore the use of these tools to efficiently register and manage various features of the Campus Agronomie Herăstrău environment. We developed an app using Field Maps that allowed us to collect data on different features of the campus, including buildings, outdoor spaces, and facilities. This comprehensive digital map created could be accessed and customized by users in real-time, allowing for quick and accurate decision-making. Our results show that the use of Field Maps provided an efficient and accurate way to register and manage different features of the campus. The app allowed us to quickly and easily collect data on various features of the campus, including their location, size, and condition. The customizable features of Field Maps also allow us to adapt the map to changing conditions. Our study highlights the potential of Field Maps as a valuable tool for efficient spatial data management. In addition, we examine the broader implications of our study, highlighting the potential for GIS and Field Maps to improve the management of complex geographic systems beyond the context of campus environments.

Key words: Field Maps, GIS, spatial data.

INTRODUCTION

In today's technologically-driven world, effective spatial data management plays a pivotal role in numerous fields, ranging from urban planning and environmental monitoring to agriculture and campus management. Campuses, being dynamic ecosystems with diverse infrastructure and facilities, require advanced tools for achieving seamless spatial data management. In this article, we present a groundbreaking approach to spatial data management for Campus Agronomie Herăstrău through the utilization of Field Maps, a fast and accurate solution that revolutionizes the way spatial data is collected, analyzed, and utilized (Smith et al., 2022). This study harnesses the capabilities of state-of-the-art Geographic Information Systems (GIS) technology, facilitating comprehensive mapping and insightful data visualization to enhance campus management and support informed decision-making (Williams et al., 2021). Over the years,

traditional manual mapping techniques have proved to be time-consuming, error-prone, and cumbersome for large-scale campuses like Agronomie Herăstrău. These methods often lead to incomplete or outdated datasets, hindering informed planning and resource allocation.

This article delves into the core features and functionalities of Field Maps, exploring its unparalleled benefits for the Campus Agronomie Herăstrău (Smith et al., 2022). From automated data collection and real-time updates to seamless integration with existing systems, this advanced tool empowers campus administrators, researchers, and planners to optimize resource allocation, minimize operational inefficiencies, and foster sustainable growth.

As the world moves towards more data-driven decision-making, the implementation of Field Maps at Campus Agronomie Herăstrău serves as a beacon of progress, showcasing how cutting-edge spatial data management tools can

lead to a greener, more efficient, and sustainable campus ecosystem (Johnson et al., 2023).

This article aims to provide valuable insights into the transformative potential of Field Maps for spatial data management and its critical role in shaping the future of campus administration and sustainable development.

In the case of the Campus Agronomie Herăstrău, accurate and up-to-date spatial data is crucial for various activities such as infrastructure planning, maintenance scheduling, security operations, and resource allocation.

MATERIALS AND METHODS

The present study employs Field Maps to capture and manage various campus features, including buildings, roads, parking lots, green spaces, and utilities. Each feature is georeferenced, enabling precise spatial analysis. The spatial data is centralized in a dedicated database, serving as a reliable and comprehensive source for different campus management departments.

To facilitate efficient data management and analysis, a user-friendly interface is developed as an integral part of the solution. Authorized personnel can access the field maps through this interface, allowing them to add new features, edit existing ones, and generate reports based on specific criteria. The system ensures seamless data synchronization between the Field Maps and the central database, ensuring consistency and data integrity.

Data collection was carried out on-site using GPS-enabled devices, such as smartphones or tablets, equipped with the Field Maps application or specialized data collection software. Navigating the campus, through a systematic approach, data on diverse features such as buildings, roads, parking lots, green spaces, and utilities was collected, as depicted in Figure 1. Top of FormBottom of Form Data collection involves capturing the geographic coordinates (latitude and longitude) of each feature and any relevant attributes or metadata.

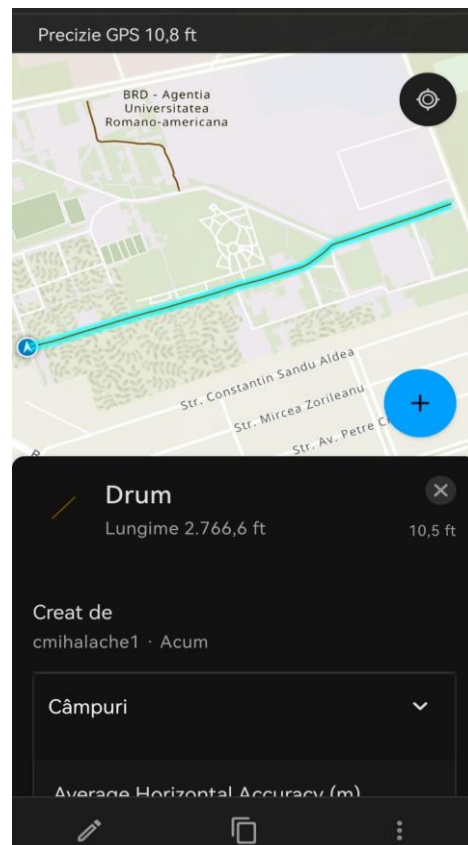


Figure 1. Road mapping

Physical visits to the locations allowed automatic capturing of precise geographic coordinates for each feature using GPS technology. Additional attributes and details about the buildings, roads, and other elements were directly inputted into the application on the devices. This systematic data collection process ensured accurate georeferencing and comprehensive documentation of the campus's features, enabling their integration into the Field Maps for further analysis and management.

The mapping process commences with the creation of a new map upon opening the application. Subsequently, specific layers are added to facilitate the mapping task, as illustrated in Figure 2. Once these preliminary steps are completed, a small black arrow emerges on the screen, signifying the user's approximate location with a precision of 10 feet (3 meters). To add new points in the designated layer and determine their precise coordinates on the map, users can simply click on the plus button, streamlining the data collection process.

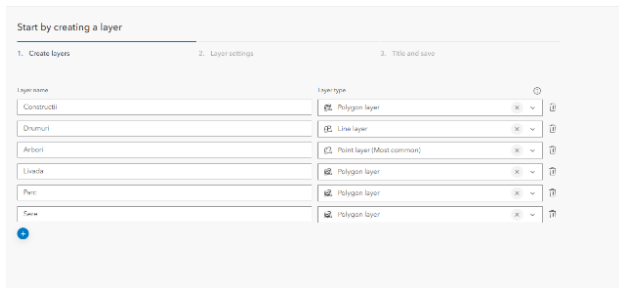


Figure 2. Creating the layers

Following the addition of a point to the map, pertinent information, such as its coordinates, area, accuracy, and length, measured using GPS, is readily displayed. The application empowers data collection in real time for various campus features, encompassing buildings, outdoor spaces, and facilities. Moreover, the flexibility to edit features in response to changes presents a valuable advantage within the app's functionality.

The symbologies for the different features have been set in Field Maps, allowing users to tailor the visual representation of each feature to their specific preferences. This capability empowers users to effectively differentiate between various features on the map, enhancing data visualization and analysis.

By adjusting the symbology in Field Maps, were assigned unique colors, shapes, or symbols to different types of features, making it easier to distinguish between buildings, roads, green spaces, or utilities at a glance. Additionally, the modification of symbologies ensured that the map's visual presentation was aligned with the objectives of the data collection project or the desired level of detail.

The symbology customization feature in Field Maps proved particularly valuable when the mapped data was publicly shared with other users, as it enhanced the overall clarity and understanding of the information presented.

RESULTS AND DISCUSSIONS

The diverse range of layers successfully added through the Field Maps application provided a comprehensive and detailed representation of the campus environment (Figure 3). The incorporation of polygon layers facilitated accurate mapping of buildings, open spaces, and parking lots, enabling a comprehensive understanding of the campus layout. Additionally, the integration of polyline layers

for roads and crossroads allowed for precise visualization of the transportation network and its connectivity.

Furthermore, the inclusion of layers within the green spaces, capturing intricate details like the distribution of trees and plants, enriched the spatial data with valuable ecological insights. This level of granularity in the mapping process contributed significantly to the overall efficacy of data analysis and decision-making.

The successful outcome of this comprehensive mapping approach further exemplifies the versatility and utility of Field Maps as a powerful spatial data management tool. By providing a robust platform for mapping and visualization, Field Maps empowers campus administrators and planners to make well-informed decisions and optimize resource allocation for improved campus management and sustainable development.

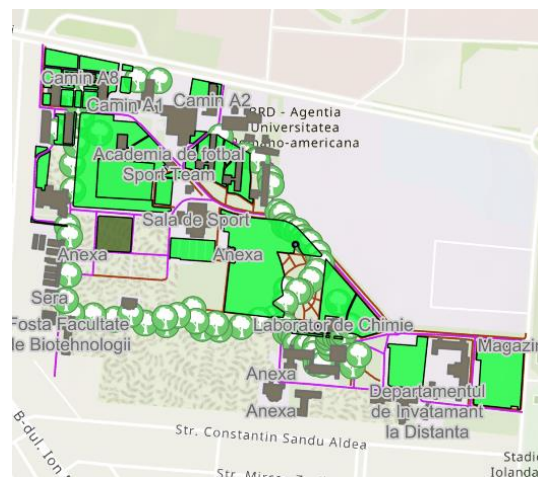


Figure 3. The final maps of recorded campus features

CONCLUSIONS

Mapping features with Field Maps proven a fast and accurate approach to spatial data management of the Campus Agronomie Herăstrău. By leveraging mapping technologies and mobile devices, the system streamlined data collection, updates, and analysis processes. The implementation of this solution improved the overall efficiency and effectiveness of campus management activities, leading to enhanced campus operations, resource utilization, and decision-making capabilities. This approach ensures high accuracy, real-time updates, and eliminates the need for manual data entry, thus minimizing human errors.

The implementation of this solution offers several significant advantages for Campus Agronomie Herăstrău. Firstly, it substantially reduces the time and effort required for spatial data management, enabling personnel to allocate resources to more critical tasks. Secondly, real-time updates ensure that the information remains current, empowering informed decision-making and effective planning. Thirdly, the system fosters collaboration among different campus management departments by providing a centralized platform for sharing and accessing spatial data.

This innovative system holds the potential to serve as an inspiration and set a new standard

for other educational institutions and urban campuses seeking effective feature mapping solutions.

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THE MODERN MEASUREMENT TECHNOLOGY APPLIED IN MINING PERIMETER EXPLOITATION ACTIVITIES

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Abstract

Modern technology combined with classical technology plays a fundamental role in engineering activities undertaken in day-to-day operations, with the aim of obtaining the necessary materials for construction or obtaining certain useful materials found near the surface. A significant contribution of this branch of engineering measurements, using modern technology, is manifested through specific studies carried out from the preliminary design phase of the exploitation to the phase where the perimeter is ecologized. The purpose of this article is to test and evaluate the accuracy of data for volumetric predictions of exploited materials, using modern technology and specialized software based on topographic altitude, through which we can create a three-dimensional model of the exploitation perimeter. For this purpose, a suitable surface exploitation was chosen as a case study, referring to the Lucaret-Sud perimeter in Timis county, where the volume of useful material forecasted in the exploitation program for the year 2023 was determined.

Key words: 3D model, Engineering measurements, Leica GS08, UAV, volumetric calculations

INTRODUCTION

The importance of the study works based on the research conducted for obtaining extensions of the mining waste and sand and gravel deposits exploitation licenses in the Lucaret Sud perimeter in Timis county. It was necessary to prepare documentation required for approval regarding the capacity to carry out mining works for mineral resources, including useful rocks and mining waste, through topographic surveys. In order to shorten the study time in this perimeter, state-of-the-art technologies were used. The data was acquired, in order to obtain the most accurate results.

In cases where we encountered areas with high inaccessibility factors, we made use of cutting-edge technologies (Bârliba, 2017).

During the World War II and the Cold War, UAV (Unmanned Aerial Vehicle) technology has significantly improved. (Haala, N et al, 2008)

Although initially notable for military reconnaissance and surveillance purposes as well as maritime surveillance, over time it has proven to be useful in engineering measurements. Subsequently, it has become increasingly recognized as a standard research

tool for acquiring detailed imagery of an area of interest and creating detailed 3D models and orthophotoplans. Precise measurements can be performed using GNSS (Global Navigation Satellite System) technology, such as GPS (Real-Time Kinematic), along with modern drone and geodetic data processing technologies.

MATERIALS AND METHODS

Engineering measurements play a crucial role in surface mining operations, supporting the smooth execution of the extraction process by providing essential information for engineering activities. New techniques and methods need to be introduced in various fields, as dynamics are inherent in our world (Casian et al, 2019).

For the extraction, transport and delivery of sand and gravel deposits from the Lucaret Sud exploitation perimeter, the necessary documentation has been prepared for its certification regarding the capacity to carry out specific works for the development and exploitation of mineral resources-useful rocks, mining residues, through topographic and geological works (Cret et al, 2021).

The surface area of the perimeter where the

exploitation works will take place is 32635.09 m^2 , equivalent to 3.26 ha, and is delimited by the following coordinates (STEREO 70 SYSTEM):

Table 1. Stereo 70 coordinates

Nr. punct	X	Y
1	524700	229500
2	524500	230500
3	524000	230500
4	524000	229500

The subject of study for the present documentation is located in Timis county and aims to obtain the exploitation permit for useful mineral substances from Lucaret Sud perimeter, through volumetric calculation of the exploitable material, using the cross-sectional method for the year 2022-2023.

In order to accurately determine the stages that form the basis of the final results, certain steps have been taken, including field reconnaissance and establishment of strategic points for commencing topographic measurements, as well as consultation of the topo-cadastral plans provided by the beneficiary.

The current technology offers new opportunities for landowners or prospective buyers: with the help of orthophotoplans, they can obtain clear and objective information about specific areas.

Regarding the topographic-cadastral perspective, recognition of the land was performed using UAV (Unmanned Aerial Vehicle) technology (Nocerino et al, 2018).

For our particular study case, we used a Phantom 4 Pro quadcopter UAV. The device is equipped with GPS and GLONASS positioning system, which allow it to quickly connect to satellites and accurately position itself in the air (Herbei et al, 2018).

Phantom 4 Pro automatically records the details of each flight performed, allowing the checks on previous flights. As for data processing using UAV platform, the flight plan for collecting ground images and determining ground control points was established using Pix4D software. Pix4D mapper is a photogrammetric software for professional mapping of images captured with the help of drones. It transforms the images into digital spatial models, both through local hardware solutions and with the help of cloud technology.



Figure 1. Phantom4 Pro UAV
(<https://www.mpb.com/en-eu/product/dji-phantom-4/sku1529737?utm>)

For centimeter-level accuracy, prior to flight control points are established on the target area using surveying instruments, which are then marked for reference.



Figure 2. Ground Control Points (GCP)

These ground control points need to appear in the images so that they can be used as reference points by the software. The steps underlying the data acquisition and processing are as follows:

- the target area is determined and the flight plan is created, which will be uploaded to the drone.

- during the flight, the UAV captures overlapping images, with a 70% overlap, and determines the geographic location of each capture.

- after landing, the images and data from the drone are downloaded and then correlated using specific software.

- the final phase is characterized by image processing, which is done using state of the art programs. This involves three important steps: image alignment (resulting in a point cloud), geometric reconstruction to calculate the three-dimensional position of each point (resulting in a three-dimensional model), and exporting the results.

In order to accurately establish the stages that will form the basis of the final results, certain steps were taken, including field reconnaissance and identification of strategic points for initiating topographic measurements, as well as consultation of previous cadastral topographic plans. The field reconnaissance was carried out using UAV (Unmanned Aerial Vehicle) technology, specifically the DJI Phantom 4 small-sized drone (Figure 1) to capture as many details as possible from the terrain.



Figure 6. Image captured with UAV (Unmanned Aerial Vehicle) technology.

In order to determine the exploitation areas, consideration was given to respecting the control points physically marked in the field. These points represent the outline of the proposed exploitation perimeter for 2023. The topographic measurements to determine the outline of the proposed exploitation and the elevation points, that are the basis of the situation plan, as well as the transverse and longitudinal profiles, in order to calculate the volume of useful or sterile material, for the Lucaret Sud perimeter, were executed in the Stereographic coordinate system 1970, with reference the level of the Black Sea using the

RTK (Real Time Kinematic) method, extending the Lucaret Sud exploitation perimeter. This plan serves as the basis for calculating the scheduled volume for each quarter.

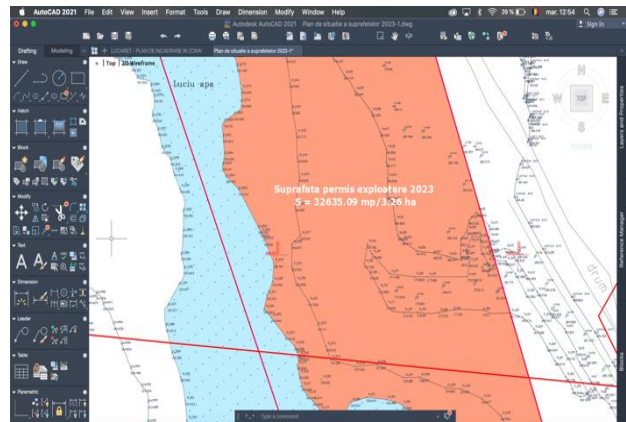


Figure 7. Up-o-date site plans with the scheduling of exploitation surfaces.

Within this studied perimeter, 7 cross-sectional profiles and 3 longitudinal profiles were established, one of which is located in the area where the deposit will be excavated, with a base elevation of +182m.

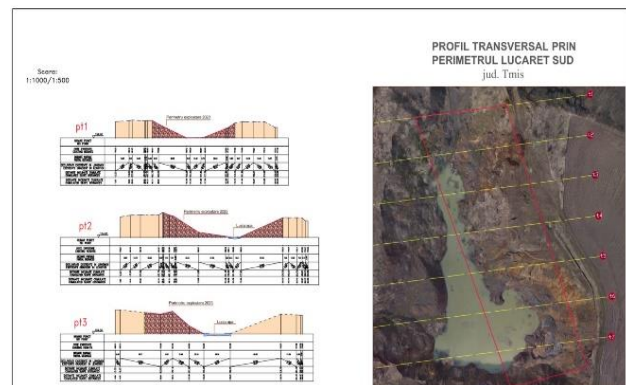


Figure 8. Cross-sectional profiles through the exploitation area.

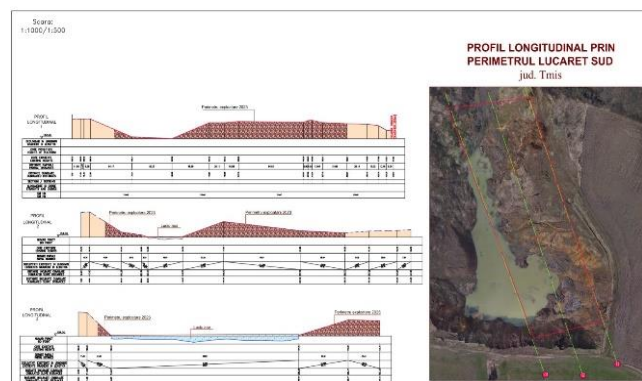


Figure 9. Longitudinal profiles through the exploitation area.

The calculation of the volumes from the transverse and longitudinal profiles is a step in establishing the main quantities of work required for the execution of excavations in the layers of useful material. was imposed by the

issuing institution of the permit. As such, the areas resulting from the profiles were calculated, and then multiplied by the applicable distance for each section, resulting in the mining volume.

BRESTOVAT, JUD. TIMIS						
No. crt.	NAME PROFILE	DISTANCE APPLICABLE m	CALCULATION OF VOLUMES			OBS
			VERTICAL SURFACE mp	VOLUME mc	VOLUME tonS	
0	1	2	3	4	5	
1	PT1	20	527,28	10.545,10	16.872,16	The applicable distance is measured and represents the distance between point P1 and ½ of the distance between T1 and T2
2	PT2	40	486,36	19.454,40	31.127,04	The applicable distance is measured and represents ½ of the distance between PT1 and PT2 and ½ of the distance between PT2 and PT3
Total Trim I (2022) = 30.000 mc						
3	PT3	40	436,70	17.467	27.947,2	The applicable distance is measured and represents ½ of the distance between T2 and T3 and ½ of the distance between T3 and T4
4	PT4	40	184,84	7.393,60	11.829,76	The applicable distance is measured and represents ½ of the distance between PT3 and PT4 and ½ of the distance between PT4 and PT5

Figure 10. Example volumetric calculation in the exploitation perimeter Brestovat, Timis

CONCLUSIONS

In conclusion, the current study is based on the premise of rational exploitation, aiming at the possibility of exploiting the mineral aggregates and their valorization from the sand and gravel deposit within the studied perimeter, considering the fact that the exploitation license 1.374/2000 for Lucaret Sud perimeter expires during the third quarter of 2022.

The main reason for an efficient and prospective exploitation is to schedule the works only for the first three quarters, as per the terms of the current permit, with the intention to obtain a 5th year extension of the exploitation license thereafter. The topographic works are carried out in accordance with the requirements imposed by the issuing authority of the permit. In order to carry out the activities of extraction, transportation, and delivery of the sand and gravel deposit from the Lucaret Sud exploitation area, the necessary documentation has been prepared for its certification regarding the capacity to perform specific works related to the

development and exploitation of mineral resources-useful rocks, through topographic, geological and other works.

The obtained results have been achieved through the use of state-of-art technologies in the field of geodetic engineering, employing modern acquisition methods, with the aim of making the achievement of objectives easy, and keeping the time factor for data acquisition and processing relatively small.

With the help of modern technologies such as drone-based surveys or geodetic data acquisition using GNSS (Global Navigation Satellite System) and GPS (Real-Time Kinematic), measurements can be carried out remotely without leaving traces along the measurement path, while other data acquisition methods can yield highly accurate results within a very short time interval. Geodetic data processing software is an integral part of modern packages, contributing to the optimization of obtaining results efficiently.

Based on the processed data results, topographic documentation is created, which includes all the

drawn elements, starting from the up-to-date topographic site plan with longitudinal and cross-sectional profiles through the Lucaret Sud exploitation, up to the volume calculation from sections, volume phased for each quarter.

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PRESERVING CULTURAL HERITAGE WITH IPHONE 3D SCANNING

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Abstract

In the recent twenty years that have passed, technology had exponential growth in a short period. Some devices included LiDAR sensors that are as old as thirteen years today, which would have cost an arm and a leg, and today we find it as a novel feature on the new iPhones. But even though they are present in our lives unknowingly, they are vastly underexploited. In this research we aim to present both advantages and disadvantages of using such complex systems in fields like surveying and terrain modeling, and if a simple iPhone 12 Pro Max using 3D processing software can replace, in the long run, the bulky but reliable 3D scanners. The building chosen is rather a complex one, of historic importance, with many statues and a decorated Art Nouveau facade, from the interbellum period: Casa Mita Biciclista.

Key words: 3D model, 3D scanner, Art Nouveau, evolution, heritage building, iPhone, Romania.

INTRODUCTION

LiDAR (Light Detection and Ranging) technology, introduced in the 2010s, has emerged as a novel approach for measuring and augmenting information in various fields, including surveying and building measurements. This technology enables the capture of 3D views and colour data, enhancing traditional measurement methods. However, assessing the current accessibility of LiDAR technology presents a complex picture that requires careful examination.

Lidar technology integration in mobile phones has gained significant attention in research and industry due to its potential applications. (Velasquez et al., 2021) discuss the expansion of spatial perception and augmented reality possibilities through mobile LiDAR. They highlight how lidar sensors enhance depth sensing, enabling more realistic and immersive Augmented Reality experiences.

Evaluation of LiDAR scanners on mobile phones is also explored in the literature. (Kuang et al., 2020) evaluate the iPhone 12 Pro's LiDAR scanner for applications in 3D modeling and virtual reality. Their findings contribute to the discussion of LiDAR's potential impact on

photography capabilities, such as enhanced portrait mode effects and low-light photography. Another significant application of LiDAR on mobile phones is in spatial mapping and 3D scanning. The depth information captured by the lidar sensor can be used to create detailed 3D models of objects and environments. This can have practical uses in architecture, interior design, and virtual reality applications, where accurate measurements and reconstructions are crucial.

While LiDAR technology on mobile phones is still relatively new, its potential impact is already being recognized. Major smartphone manufacturers have started integrating lidar sensors into their flagship devices, and developers are actively exploring innovative use cases. As the technology continues to advance and become more accessible, we can expect to see further integration of LiDAR into everyday mobile experiences, unlocking new possibilities for creativity, productivity, and interaction.

The objective of this research was to investigate the viability of employing alternative methods for 3D scanning, specifically exploring the potential of utilizing portable devices equipped with integrated LiDAR scanner capabilities to obtain reliable and usable results.

For the study conducted, a monument representative for the Interbellum Bucharest was chosen: Casa Mita Biciclista (Figure 1). The house belonged to the demimonde Maria Mihaescu, who received it as a gift from Ferdinand, King of the Romanian Kingdom. Its structure was finalized in 1910 and it is a combination of Art Nouveau and Belles-Artes styles. Representative and important for this study is the facade, which is highly ornated around the entrance and windows, and adorned with detailed statues. By selecting Casa Mita Biciclista, the study aims to highlight the efficacy of the alternative scanning method in capturing and preserving the architectural heritage of this iconic building.



Figure 1. Casa Mita Biciclista

MATERIALS AND METHODS

For the purpose of capturing detailed scans of the building to generate a comprehensive 3D model, the scanning phase involved utilizing the built-in LiDAR sensor of an iPhone 12 Pro Max. The obtained LiDAR data was then processed using the Polycam software, which harnessed the capabilities of the device's camera and advanced algorithms to facilitate efficient and accurate data processing.

The scanning area was carefully chosen in accordance with traffic regulations and visiting hours (Figure 2). Permission was obtained to conduct the fieldwork on the selected site, which falls under the public domain. Specifically, the front facade of the building was identified as the target area for scanning.

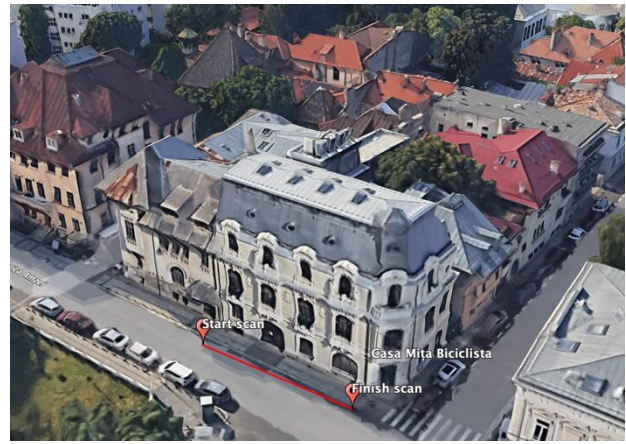


Figure 2. Area for scanning

Two scanning distances were considered for data acquisition: 10 meters and 3 meters from the house. These distances were strategically determined to capture the necessary level of detail while maintaining appropriate spatial coverage (Figure 3).

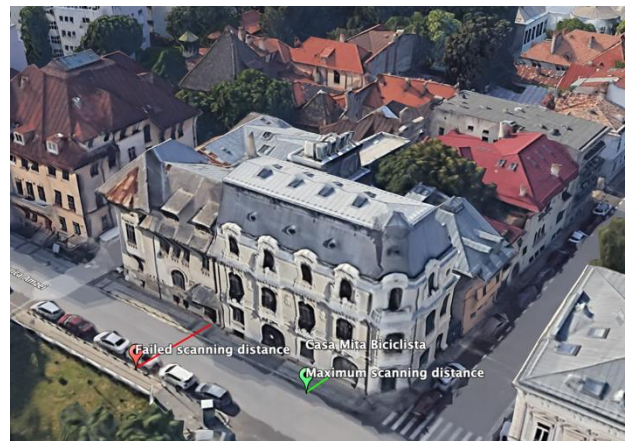


Figure 3. The two scanning distances tested

To minimize potential scanning imperfections caused by light interference, a key consideration was the selection of suitable weather conditions. The scanning process was scheduled to take place on days with direct sunlight or, at a minimum, under cloudy skies. This precaution aimed to ensure optimal data capture, mitigating any adverse effects caused by light refraction during precipitation events.

Prior to commencing the scanning process, a series of thorough checks and assessments were conducted to ensure the smooth and successful execution of the scanning procedure. These assessments involved evaluating the internal memory capacity, ensuring the availability of sufficient cloud storage, establishing a stable internet connection, and verifying the optimal

functioning of the camera and LiDAR sensors. Additionally, precautions were taken to ensure the cleanliness and proper maintenance of these sensors, eliminating any potential debris or malfunctions that could hinder the scanning process.

The scanning route was designed to incorporate sufficient overlap between consecutive scans, facilitating accurate registration and alignment of the resulting point cloud data.

For the specific area targeted in the scanning process, the entire procedure was efficiently executed, taking less than 5 minutes to complete. This brief timeframe was instrumental in capturing the required data with minimal risk of encountering disruptions or inconsistencies in the acquired scans. By optimizing the scanning process, the study ensured the swift acquisition of the necessary information while maintaining the integrity and accuracy of the collected data. Once the scanning was completed (Figure 4), the software Polycam was used to process the cloud point and create the 3D model of the building.



Figure 4. The scanned area

The application uses three simple software settings that we can choose, such as:

- Voxel Size (the size of the geometrical shapes in which the laser from the scanner is emitted),
- Simplification (the clarity of the 3D model)
- Depth Range (the distance from which the cloud point is collected).

For visualisation the 3D Model, Polycam software allows many exporting options for the

model, the most used being OBJ, PLY, USDZ, etc. These formats are commonly used for 3D printing of the model and visualisation in Augmented Reality and Computer Aided Design.

RESULTS AND DISCUSSIONS

During the processing stage, Polycam software computed an average of approximately 225,000 points from the captured data (Figure 5).

Although this number may seem relatively low when compared to the average of around 2 million points generated by conventional 3D scanners, considering the specific chipset and sensor utilized, the resulting model achieved an average quality level. This model proves to be suitable for accurate digital measurements, with an acceptable error margin of 1-2 centimeters. These findings hold true specifically for the scanned area, demonstrating the effectiveness of the scanning method in generating a reliable model for precise measurements within the designated region.



Figure 5. Processing the point cloud

The 3D model resulted encompasses approximately 70-75% of the intricate details present in the building. Architectural elements such as statues and window arches were faithfully represented, exhibiting a high level of accuracy in the model. However, it is important

to note that there were instances of failed captures, particularly where the environment allowed for laser refraction, notably on windows and glass doors (Figure 6 and Figure 7).



Figure 6. 3D Model generated



Figure 7. Details on the 3D Model

Upon reviewing the result, this method of 3D scanning can be used successfully to scan objects. From statues to large houses and cultural sites, having a fast and reliable method of scanning can not only be used to preserve the information but also for educational purposes of future archaeologists, historians and most importantly, geodetic engineers and architects. The costs of implementing are low since it uses only the smartphone with the LiDAR sensor and an application that can be downloaded easily.

CONCLUSIONS

The 3D model that resulted from the scan of the building is a somewhat functional product. Distances can be measured within the Polycam app and it can be used for projects in Computer Aided Design software. Being a smartphone sensor, it lacks the clarity of a professional scanning solution and pay-for-use software, but it can be used safely for educational purposes or comparisons and exercising 3D modelling. With time, solutions like this will most likely replace the bulky 3D scanners that are now used on a large scale in favour of portability.

Fast 3D scanning can also be implemented into a Building Information Model (BIM). This process involves a database that combines a 3D model of a building with a spatial database and assets, that allows for digital planning. It can be used, for example, for the design and computer modeling of a house, or a civilian building, such as schools, roads, or even entire neighborhoods. This method also is environmentally friendly, and allows for Artificial Reality examination, cost estimates for materials, and many more uses. In the long run, every building that is of importance should implement a BIM, as a standard for cultural preservation and easy restoration.

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THE TOPOGRAPHICAL STUDY FOR THE UPGRADING OF ELECTRIC PUBLIC TRANSPORT AND THE DEVELOPMENT OF THE NON-MOTORIZED TRANSPORT INFRASTRUCTURE OF THE MUNICIPALITY OF REȘIȚA

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Abstract

The purpose of the topographical survey was to collect data from the field in order to fully upgrade the electric public transport and improving the non-motorized transport infrastructure in the Municipality of Reșița.

The total length of the route that is the subject of this project is 8.5 km, this route includes the following streets: Republic Boulevard, Caransebeșului Route, Timișoarei Route, The December Revolution Boulevard, Ion Luca Caragiale Street, Freedom Street, Traian Lalescu Street, Paul Iorgovici Street and Republic Square.

From the route created for the electric transport infrastructure, the paper presents the first section that includes the part of the roundabout that connects with the Intim passage, that crosses over the railway that connects South Reșița and North Reșița. The study presents the following stages in the fulfilment of the project: the stage of organisation necessary for the realisation of the specialised works, the materials and methods used in carrying out the topographic survey, the processing of the data in order to create the topographical technical documentation that will be made available to the designer.

Key words: *electric transport infrastructure, situation plan, topographic survey.*

INTRODUCTION

Reșița is the municipality residence of Caraș-Severin county, located in the Banat area of Romania. This municipality consists of the localities: Călnic, Cuptoare, Doman, Reșița (residence), Secu, Țerova and Moniom. The municipality of Reșița is located in the south-west part of Romania, more precisely in the north-west part of the county, on the middle course of the Bârzava river. The city of Reșița is known as the oldest steelmaking center in Romania. Being an old steelmaking center town, unfortunately the world did not see a potential in it and were not interested in the development of this city, all this until now when the possibility of making a change that will modify and develop this city was found. Already in 2015, a large-scale project was started, both in terms of urban and economic development, which continues to this day. The municipality of Reșița was in great need of a

change in order to offer a more sustainable and good future. This work is based only on a section of the urban development that contains the section for the upgrade of electric public transport and the arrangement of the non-motorized transport infrastructure of the municipality of Reșița.

A particularity of the Reșița municipality, created by its location in a predominantly mountainous chain, is the increase in the difficulty of using the GPS system. The difficulty is created due to the reduction of the angle of incidence between the horizon line and the GNSS system receiver, thus the relief obturating the transmission of certain satellite signals. A solution to avoid these reliability problems is the use of the Base-Rover method, which involves placing a GNSS receiver on a known fixed point, which has a larger opening to the horizon, to send the corrections in real time, through radio signals, to the device with which measurements are made (Rover). This

method is not affected by the obstacles between the base and the Rover, and the reliability of the signal is superior.

MATERIALS AND METHODS

After analysing the work route, it was concluded that, in order to carry out a correct survey, two work methods are necessary, namely: the GPS method, the topographic survey carried out with the total station.

GPS method. Positioning with the help of GPS technology is achieved by determining the distances between the station point and at least 4 visible GPS satellites. The support points will be determined with the help of GPS using the static method, with the specification that for measurements with the total station, a much larger number of support points is needed. The static method uses the signals received from the satellites and triangulates the position on the globe, after which, the file created with the measurements, is processed for the precise determination of the point on which it was stationed. The GNSS system records the triangulation calculation at a frequency of one measurement per second, also called epoch. If the triangulation rule of at least 4 satellites transmitting to the receiver cannot be respected, it does not perform the measurement.



Figure 1. Receiver Trimble R8s

(https://surprise-cord.squarespace.com/products-1/trimble-r8s-gnss-receiver?fbclid=IwAR39pkbyEl_xx2yMOZUIWgiqzZMy5ZptKen9JajHFeqG-mQbGGWkWnFNdkM)

A Trimble R8s and a Trimble TSC5 controller were used to perform measurements involving GPS. Each Trimble R8s receiver integrates Trimble 360 tracking technology that supports

signals from all existing and planned satellite constellations and augmented systems. The Trimble R8s includes two Maxwell™ 6 processors along with 440 GNSS channels. It is capable of tracking satellite systems including GPS, GLONASS, Galileo, BeiDou and QZSS. Together with the CMRx correction protocol, which offers unprecedented compressed corrections, the safest positioning is obtained. The Trimble® TSC5 is an Android-based control unit with a 5” screen and full keyboard, ensuring fast and efficient operation, even while wearing gloves. Rugged yet lightweight with all-day battery life, the TSC5 is easy to carry and easy to use. Combined with Trimble Access™ software for accurate field data collection, the TSC5 offers the ideal combination of high performance and reliability you have come to expect from Trimble.

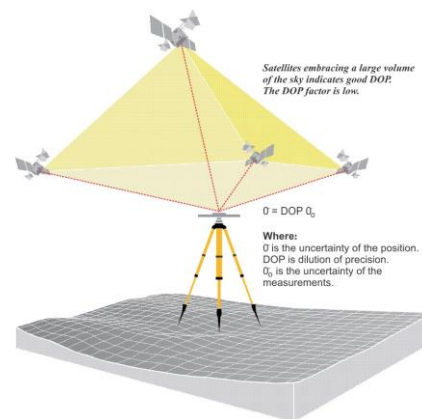


Figure 2. The principle of GPS measurement

(<https://www.e-education.psu.edu/geog862/print/17.html?fbclid=IwAR1Vyghwg5IHCiWuwc9yrd4JAB-vu-Za09HCVrWw1J0L6bR-tkmifC8UW3A>)

So, the static method can determine with an accuracy of ± 5 mm, the Cartesian coordinates of the support point.

The topographic survey performed with the total station. The total station is used for an increased precision and accuracy. The total station is the device for measuring horizontal and vertical angles and the electronic measurement of distances with the possibility of storing the measured data. Most of the time, the measurements are made by the method of closed traversing.

This method, although very precise, is slow and requires additional processing, as it is necessary to compensate the measurements made with the total station. The determination of the elevations of the support points and the landmarks in the traversing is done with the level by the geometric levelling method.



Figure 3. Total Station Trimble S7

(https://www.giscad.ro/aparat/trimble-s7/?fbclid=IwAR2dm4h17UXzD0aA8_cc2FKGMtVyiEtSOXaeggYVnSv1fTRHJW3_ig-ILYA)

For the total station measurement method was used a Trimble S7. The Trimble® S7 total station combines a number of features such as scanning, land photogrammetry and surveying in one powerful technical solution. The Trimble S7 is an efficient system created for performing topographical measurements that allows you to adapt to any situation in the field, to achieve high productivity. By combining proven SureScan, Trimble VISION™, FineLock™ and DR Plus technologies with many other features, you will achieve the results you want much faster and more accurately.

RESULTS AND DISCUSSIONS

Measurement planning

For this work were established the following topographic objectives:

- Improvement of the geometry of the route in plan and in longitudinal profile (rectification of curves and framing of profile elements in the provisions of the regulations in force).
- Curves and level differences of the land.
- Geometry of the path in transversal and longitudinal profile.
- Water collection and evacuation.

- The nature and location of existing and projected underground and above-ground infrastructure.
- Level crossings over the railway.
- Systematization of railway line devices in stations.
- Composition of the road system of the streets.
- Level intersections, uneven intersections, industrial accesses, etc.
- The shape and size of the adjacent buildings.
- The size of the transport network (roadway, sidewalks, green spaces).
- Correct functioning of the topographic equipment.

The stages of the topographic survey

Designing, with the aim of upgrading the electric public transport and setting up the transport infrastructure, requires intensive planning on the decisions regarding geometric elements, infrastructure, materials used, methods used for construction, but also its correlation with the regulations in force that refer both to the transport part in common as well as on the road and pedestrian side.

The feasibility study

This study is a document that presents the projects ability to fulfil certain technical requirements. Before building anything, you need a feasibility study. A feasibility study means a technical-economic documentation that helps the designer to make the best decisions.

The feasibility study is constituted by the topographic measurements and their digitization, which aim to recognise the land for design, and by the geotechnical study which is necessary to establish the elasticity of the bearing layer and helps to establish the bearing capacity of the soil to support the road structure together with the vehicles that will travel on the road, and the vibrations produced by traffic.

Since we are talking about the railway, the topographic elevations must have a certain precision.

Therefore, the Trimble S7 total station was used to perform the surveys.

A Trimble R8s, GNSS system was used together with a Trimble TSC5 controller to determine the support points required for the closed traversing.

Through the static method, the coordinates of the support points in the Stereo 1970 coordinate system formed on the secant plan to the Krasovsky 1940 ellipsoid are obtained with high precision.

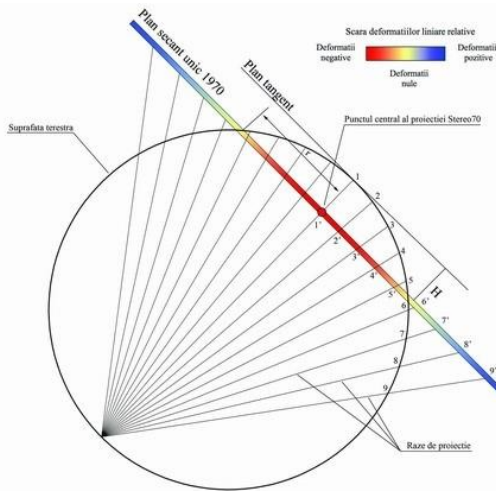


Figure 4. The projection of points on the earth's surface on the Stereographic projection plan 1970 (<https://www.topo-online.ro/ro/stereo70.php>)

Performing of topographic surveys

As previously mentioned, the closed traversing was used to perform the measurements. This method involved setting up the total station device on a support point previously determined by the static GPS method, and using another support point with known coordinates as the bearing. The traverse and the survey were carried out simultaneously, at the end having as the last station a known support point, from which another point with known coordinates was targeted.

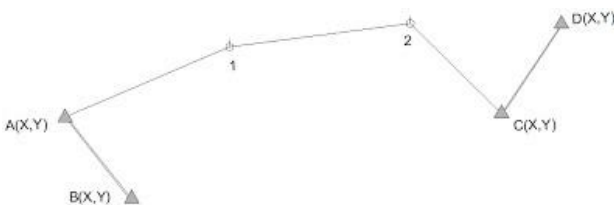


Figure 5. Representation of the method of closed traversing

(<https://www.ct.upt.ro/studenti/cursuri/jianu/topografie%202.pdf?fbclid=IwAR1BVEcuNYhD8EjDiFa8JDN7wDtJrXZ8inYmfQiS5DfLIYhg0CXCWk3RQ3I>)

So, by closing the traverse on known support points, it was possible to compensate the measurements. After the compensation of the measurements, the elevation processing, the

construction of polylines, polygons and the placement of specific symbols represented by conventional signs were carried out in the office stage.

The office stage

From the processing of the elevations resulted location plans that are part of the topographic study.

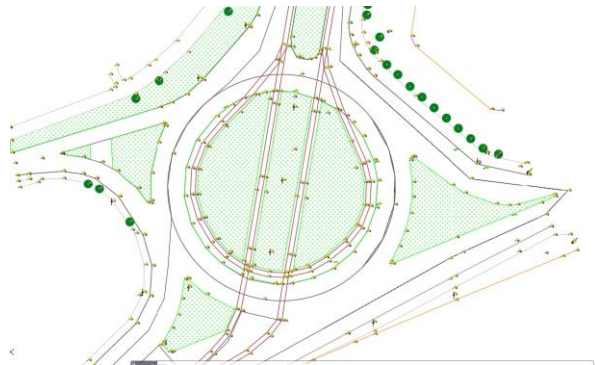


Figure 6. The location plan of the roundabout

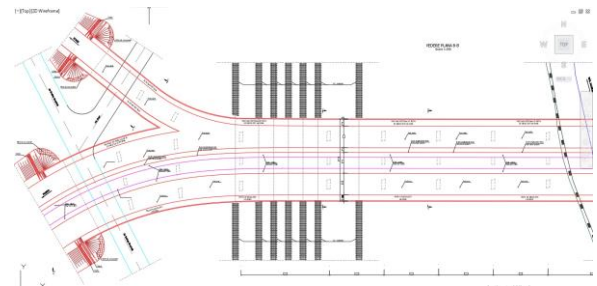


Figure 7. The location plan of the bridge from Intim that crosses the railway



Figure 8. The situation plan

After processing the data taken from the field, both transversal and longitudinal profiles are also obtained. Transversal profiles represent the image in section of the road, for a better

visualization of the differences in elevation between the curbs, the road slope, the tramline.

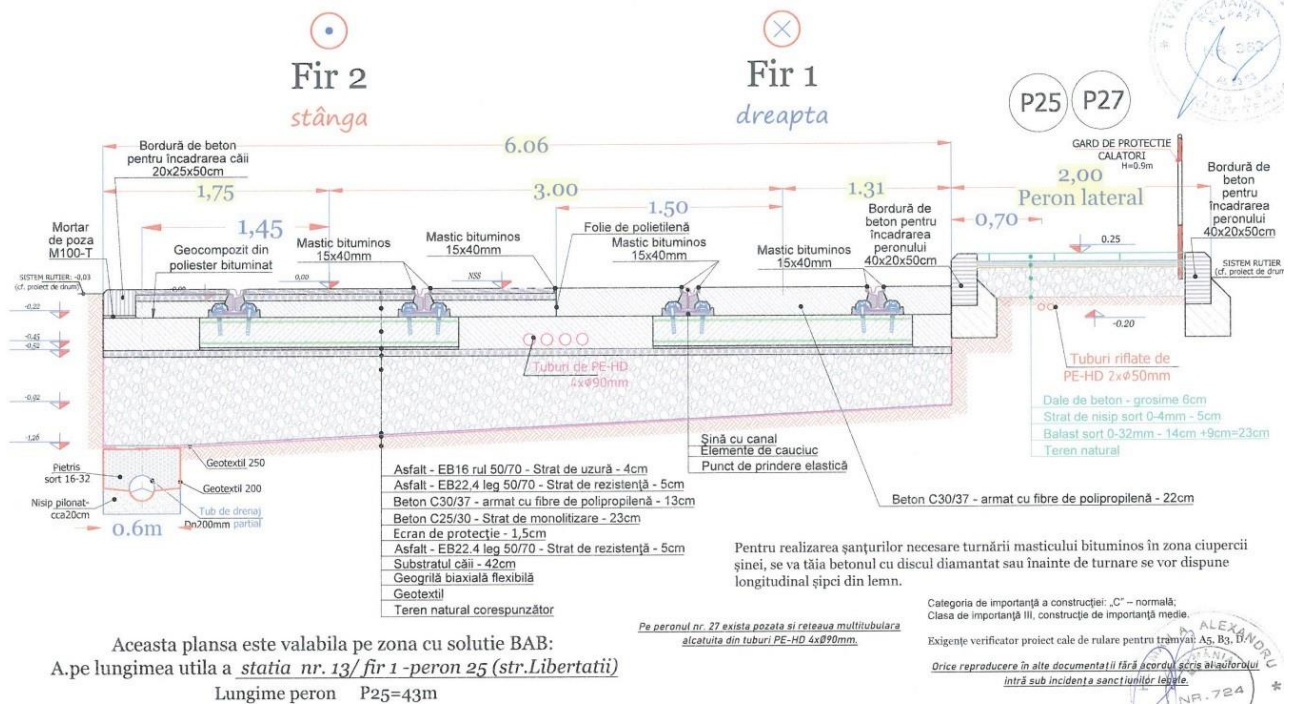


Figure 9. The transversal profile section

Longitudinal profiles represent the differences in elevation of an element in the survey, in

our case, the most important being the tramline.

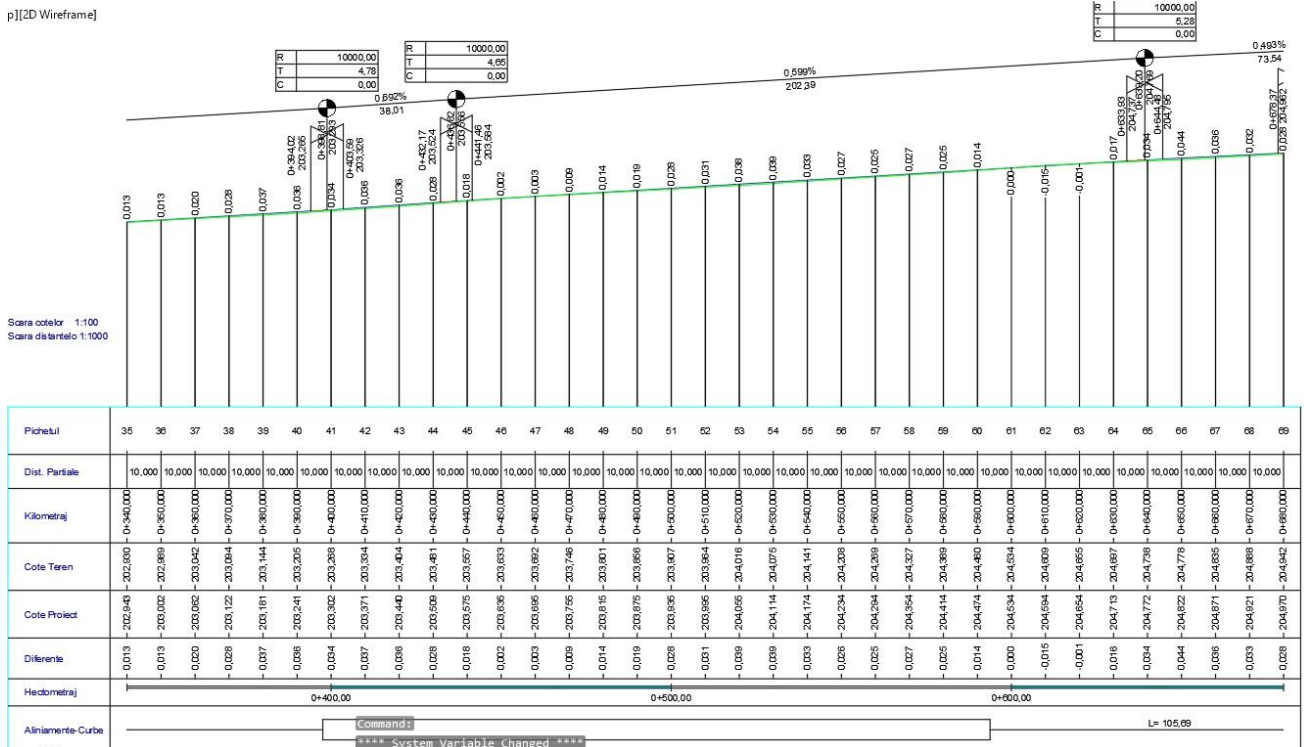


Figure 10. The longitudinal profile section

CONCLUSIONS

This paper presented the use of modern techniques used in a special topographic survey, regarding the upgrading of electric public transport and the development of non-motorized transport infrastructure in the Municipality of Reșița.

The methods used in the performing of topographic surveys fulfil the legislation requirements in force in Romania.

The topographic surveys carried out by the method of closed traversing is facilitated at the present time by the use of advanced technologies of total stations with superior working and precision characteristics.

However, this technology requires special attention from the operators and a longer time for the execution of the works in the field.

Data processing requires the use of specialized programs for the accurate creation of longitudinal and transversal profiles, such as TopoLT, ProfLT.

The emergence of this technology determines a change in the structure of the work procedures that result in obtaining a high degree of automation and an increased yield.

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STUDY USING LiDAR TECHNOLOGY ON TIME MODIFICATIONS OF THE PILCOMAYO HYDROGRAPHIC BASIN IN PARAGUAY DURING 2018-2020

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Abstract

The main objective of the project, entitled "STUDY WITH THE HELP OF LIDAR TECHNOLOGY ON CHANGES OVER TIME OF THE PILCOMAYO HYDROGRAPHIC BASIN IN PARAGUAY IN THE PERIOD 2018-2020", is to create, with the help of specialized programs and software, the digital model of the land and the model digital of the surface, for a portion of the Pilcomayo River, located in the central part of South America.

The final result must come in support of the people who will draw up flood scenarios and plans, due to the fact that the river is constantly changing, threatening both the flora and fauna of the area, but also the communities of people near its banks.

As part of the project, volumetric calculations will also be made, which will result in the quantities of excavation and filling that will be necessary to combat possible floods.

INTRODUCTION

The main objective of the project is to create, using specialized programs and software, the digital terrain model and the digital surface model for a portion of the Pilcomayo River located in the central part of South America.

Over time, numerous scientific research studies have been conducted to understand its behaviour, as it is a river constantly changing.

It is famous for its flood period marked by the rainy season, occurring in the months of December and January. The flooding starts in February and reaches its peak level in April. The river's descending period occurs between the months of May and December.

THE WORKING METHODOLOGY

The equipment used to obtain the data:
Bell 206 helicopter (ZP-HCH)



Figure 1. The equipment used

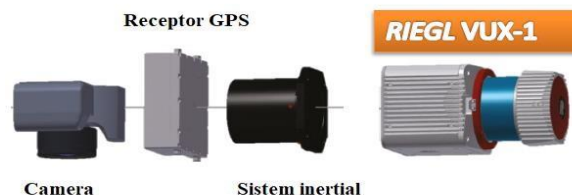


Figure 2. Components

On the digital model, the changes that have occurred over time on the terrain can be observed most effectively. In practice, this serves as the basis for analysis. Volumetric calculations will be performed and the evolution of the river banks will be analyzed.

Based on the resulting digital models, flood scenarios can be created to observe how the terrain would behave in the event of floods. The evolution of the Pilcomayo River is constantly monitored, with periodic scans being conducted on it.

The control points were materialized with hydraulic markings made of concrete with a bronze plate at the central point, similar to the markings of the national geodetic network.

They were geolocated using a GPS K9 device.



Figure 3. Control point

CREATING THE DIGITAL TERRAIN MODEL

The Digital Terrain Model is a three-dimensional mathematical representation, to scale, in digital format, of the terrain in a specific area.

It accurately describes an extensive land surface, often inaccessible or difficult to access, such as vegetation-covered areas or mountainous regions, where the use of traditional surveying techniques would be nearly impossible to implement in practice

The steps involved in creating the digital terrain model in this work are:

1. Importing the lidar data into the specialized software Envi LiDAR
2. Selecting the processing parameters
3. Processing the data
4. Displaying the results
5. Importing the data into Global Mapper

6. DTM processing
7. Processing the parameters
8. Final DTM result

Specialized programs and software for creating the digital terrain model:

Envi Lidar

The ENVI software product for satellite image analysis uses mathematically proven analyses to deliver highly accurate results. Private companies, as well as other organizations, use ENVI because it integrates with existing workflows, supports today's most popular sensors, and can be easily customized to meet unique project requirements.

Initially, we imported the data obtained from the scanning process in 2018.

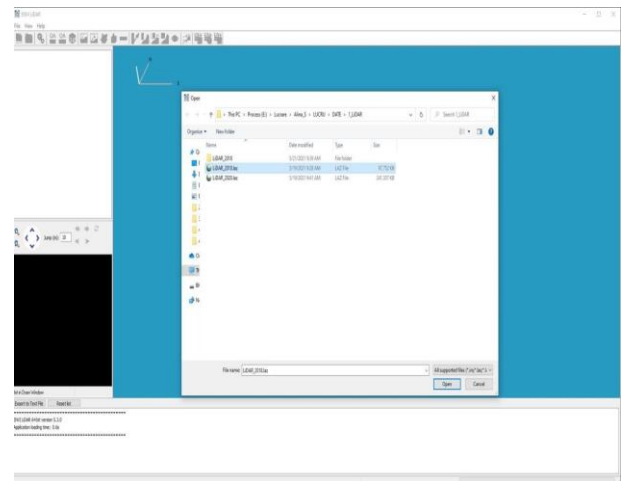


Figure 4. Importing LiDAR data

In the image below, after the import, we can observe the presence of "noise" points, which will be of no use to us.

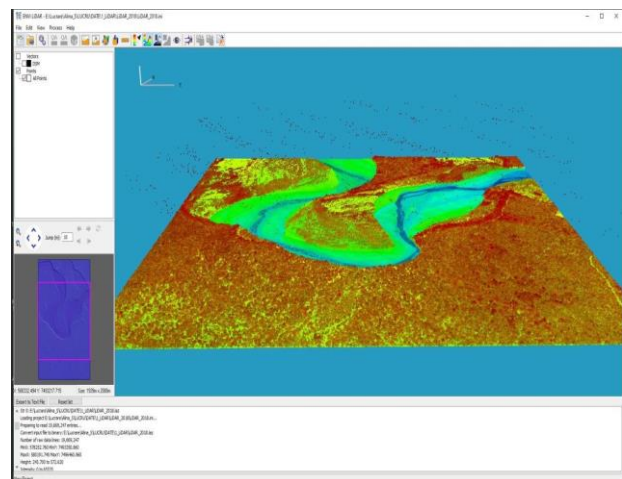


Figure 5. Importing LiDAR data

For parameter processing, we selected the options "Produce DSM, P. DEM, P. Trees, P. Point Cloud." We chose the U.T.M. projection system, WGS84 datum, and Zone 20S. Furthermore, we selected a resolution of 1m/pixel and then waited for the point cloud processing to complete.

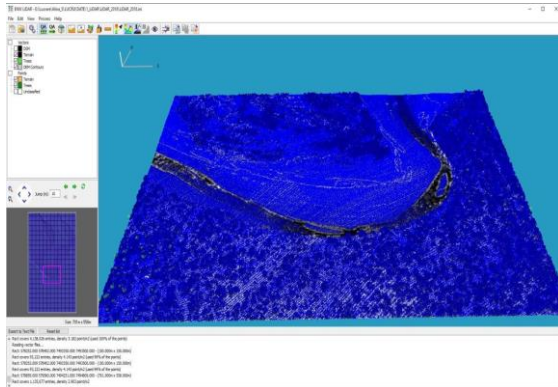


Figure 6. Envi LiDAR result

Global Mapper

Global Mapper is a Geographic Information System (GIS) software that provides users with the ability to create, edit, analyze, and visualize geospatial information. This software is developed by Blue Marble Geographics and offers a wide range of features, including data import and export, geospatial data analysis, map creation, and visualization tools. It is available for both personal and commercial use. Initially, we started by importing the data into the Global Mapper software.

Once the data import was completed, we proceeded to the stage of processing the digital terrain model. From the "Analysis" window, we selected the option "Create Elevation Grid from 3D Vector/Lidar Data."

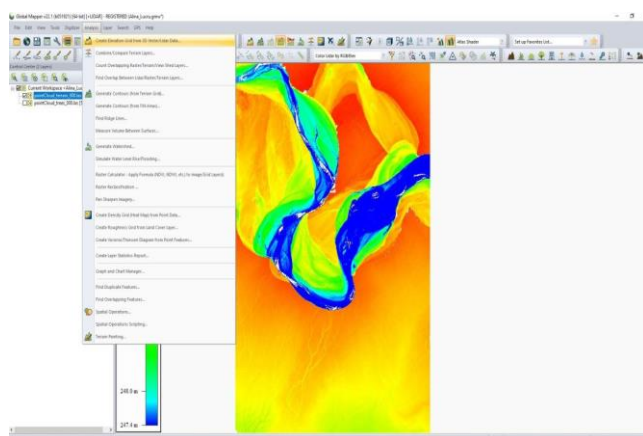


Figure 7. DTM processing

Then we selected the option "pointCloud terrain". In the next window, we filled in the "Layer" field with the desired type of digital model, specifically DTM. We waited for the processing of parameters, and finally, the Digital Terrain Model (DTM) was generated.

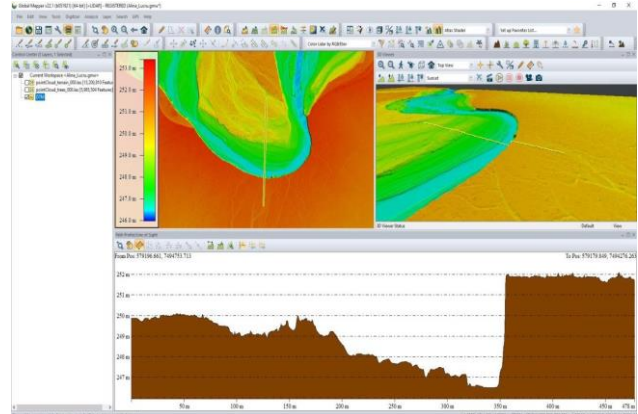


Figure 8. DTM result

Continuing the same process, we proceeded to obtain the Digital Surface Model (DSM), with the only difference being the selection of the option "Layer - DSM."

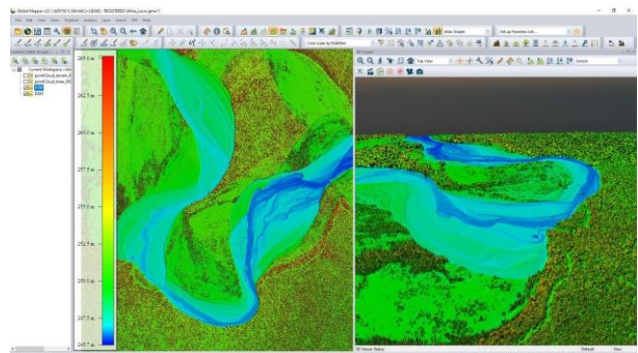


Figure 9. DSM result

In the image below, you can observe the difference between the created DTM and DSM:

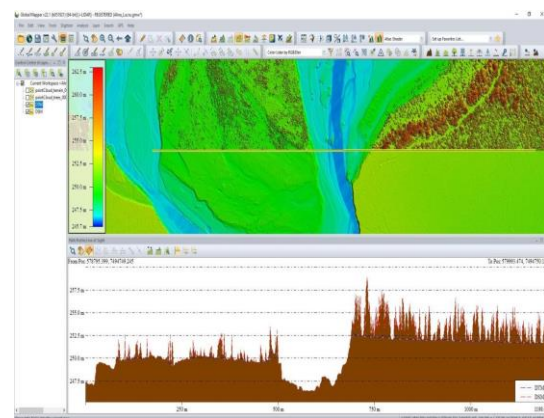


Figure 10. Comparison between DTM – DSM

The differences between the digital terrain model (DTM) and the digital surface model (DSM) are clearly visible at first glance. The DSM provides detailed information about vegetation cover and areas that may appear inaccessible.

In the following images, we will demonstrate how two images can be displayed simultaneously in Global Mapper software:

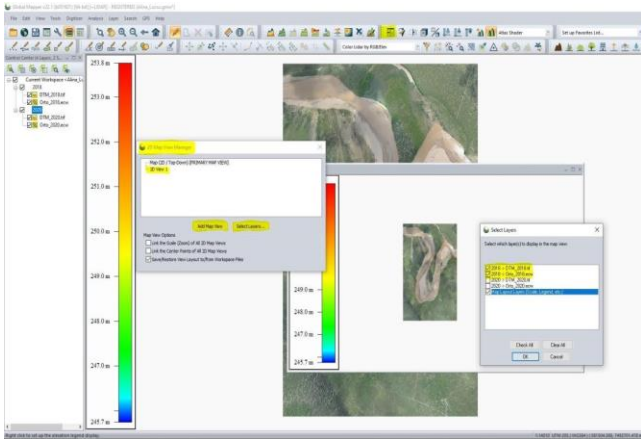


Figure 11. Simultaneous visualization

Here, we have presented a concurrent view of an orthophotoplan from 2018 and another one from 2020. The differences are extremely visible.

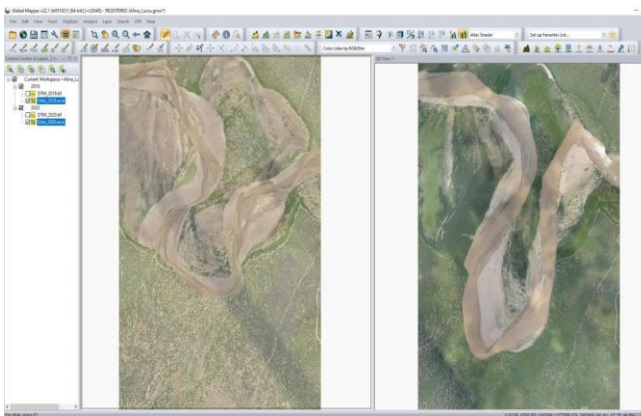


Figure 12. Ortho visualization 2018-2020

We repeated the same steps for the data obtained from the 2020 scanning, and now we will present a series of comparisons and changes over the course of these two years.

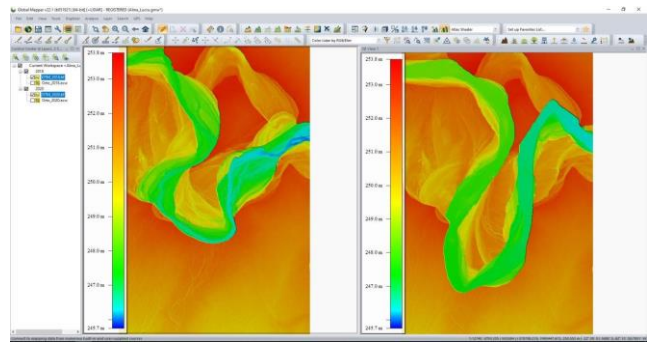


Figure 13. Visualization DTM 2018-2020

In the current image, the two digital terrain models from the two years are displayed. To compare the two digital terrain models, we selected the "Combine/Compare Terrain Layers" command from the "Analysis" window.

In the following images, I wanted to highlight the changes that occurred over the course of two years in our area of interest.

For this, we used a tool in Global Mapper that allows us to perform operations on the analyzed surfaces.

In the initial phase, we wanted to see where and by how much the land elevation has increased due to the river action. To achieve this, we filtered the created raster to highlight positive differences.

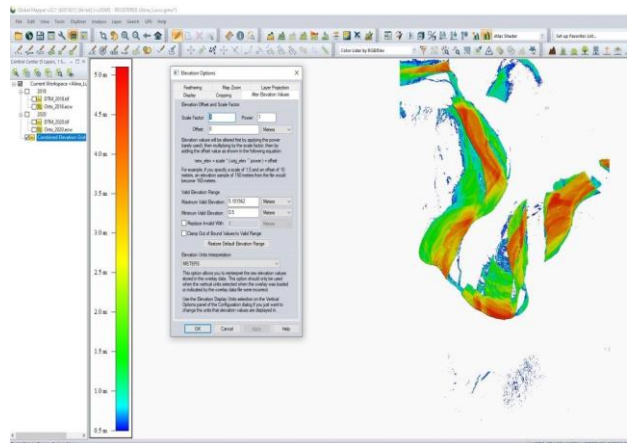


Figure 14. Positive changes: 2018-2020

For the next image, we wanted to visualize the land eroded as a result of the river action. We filtered the data to highlight negative differences.

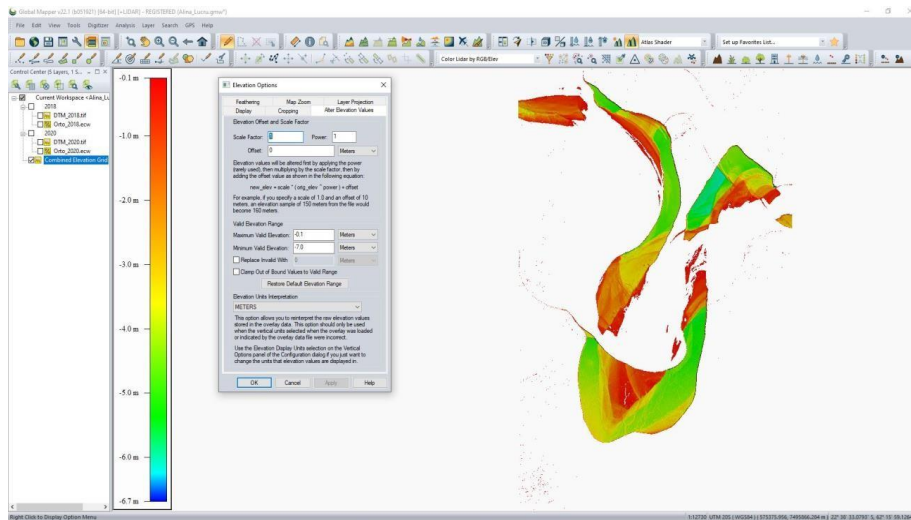


Figure 15. Negative changes 2018-2020

ANALYSIS AND CONCLUSIONS

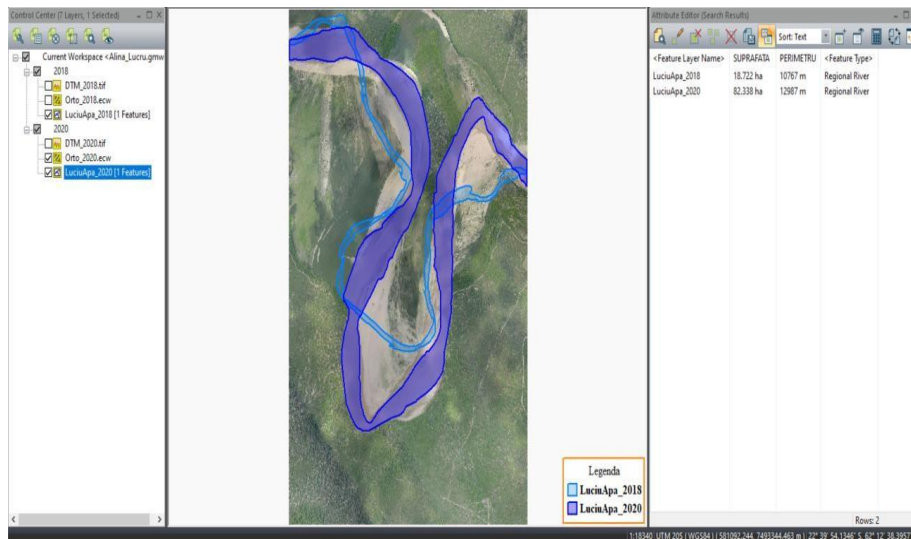


Figure 16. Comparison of the surface

The surface and perimeter changes over the course of the two years are clearly visible. The total calculated volume from the two

surfaces is 6,423,580.2 m³. The excavation area was 126.96 hectares, and the fill area was 3,147,228.3 m³.

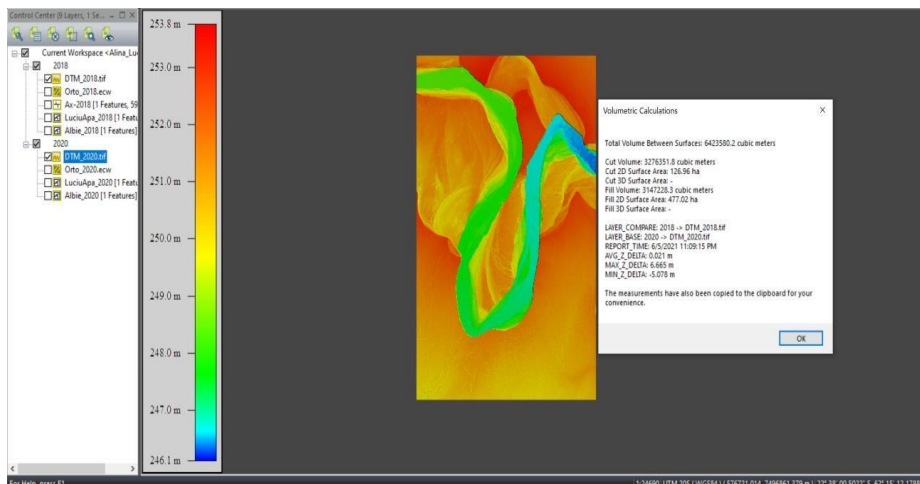


Figure 17. Excavation-Fill Volume

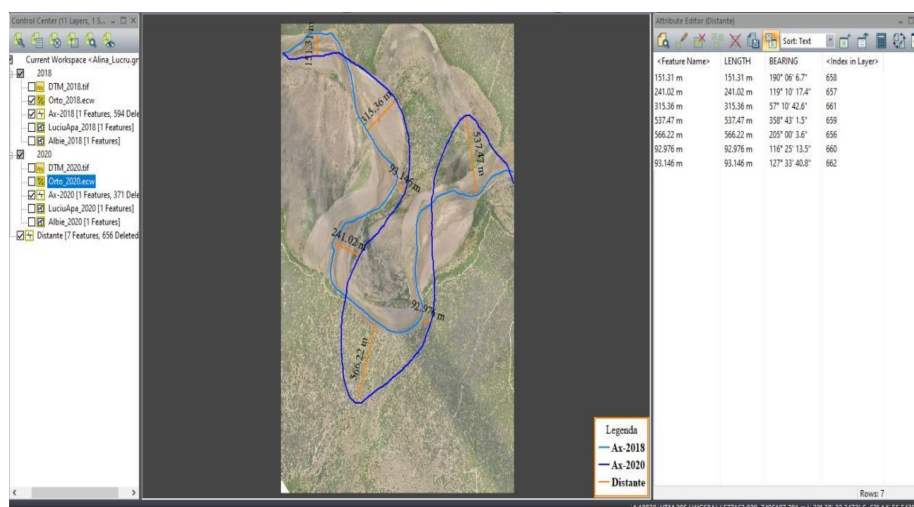


Figure 18. Distances

In the image above, the changes in the river over a period of 2 years are represented by distances.

It can be observed that the movement of the riverbank is very noticeable, highlighting the importance of constant river monitoring.

CONCLUSIONS

The ability to perform rapid and accurate measurements over large areas at an optimal cost, as well as the capability to simultaneously acquire other data sources such as high-resolution aerial imagery, make airborne laser scanning technology an important tool for numerous applications related to planning and land management.

The measurement of surface areas traversed by water has become essential for evaluating sediment volumes, analyzing changes in water courses, calculating water velocity and level dynamics, and describing the structure and geomorphological changes of territories.

In this study, the Riegl VUX-1 airborne sensor was used. It can be easily mounted on any type of aircraft, such as airplanes or helicopters. The advantage of the equipment used lies in its accuracy and the quality of the final product it produces.

Following the scanning process, the digital terrain model and digital surface model were obtained, aiming to prevent potential natural disasters such as floods, as the river is constantly changing.

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GEOSPATIAL TECHNOLOGIES IN REMOTE SENSING IMAGE PROCESSING

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Abstract

The main purpose of this paper is to study the dynamics of Timiș county based on spectral information obtained from Landsat 8 satellite imagery. The vegetation dynamic has been expressed differently from the normalized difference indices: NDVI, NDWI, NDSI, NDMI, NDBR and NDBI. With the help of the Arc Map software, one can create maps based on normalized difference indices. Each index has a certain representation: NDVI – vegetation, NDWI – water, NDSI – snow, NDMI – humidity, NDBR – potential of burning vegetation and NDBI – constructions. The presented results present a new, up-to-date method for monitoring the earth's surface based on geomatics technologies.

Key words: ArcGIS, Landsat 8, maps, NDVI, normalized indices

INTRODUCTION

In the past couple of years, remote sensing has witnessed impressive development considering that the first models of analysis and acquisition from a distance have appeared around four to five decades ago. This is based on the fact that the objects and the material processes send different corpuscular emanations and different types of radiation in the surrounding space; that, or the fact that they are joined by force fields with great spatial extension. Depending on the model or means applied, remote sensing may be passive – when reflected or radiated natural energy is used- and active – when remote sensing makes use of artificial radiation, which is being emitted in order to be make contact with certain objects and/or investigated phenomena.

The principles of passive remote sensing imply the acquisition of imagery related to phenomena or objects located on earth's surface, taken from a distance, using only the emission of electromagnetic radiation. The principles of active remote sensing utilize artificially generated electromagnetic radiation, to obtain imagery related to the aforementioned objects of interest. The most frequently used are radar

systems (with microwaves), lidar (with polarized light) and sonar (with sound waves). The principle of multispectral scanning is one of the more widely used ones since it can produce high quality imagery at the level of spectral and spatial resolution. The principle, perfected in the past three decades, relies on the fact that, in nature, every object or phenomena emits electromagnetic radiation, depending on its physical and chemical proprieties. These emissions allow further data acquisition, interpretation and analysis.

MATERIALS AND METHODS

Geographic information systems are computer systems capable of holding and using data describing places on the Earth's surface (Herbei, 2015).

The Landsat Mission was a National Aeronautics and Space Administration (NASA) initiated experimental and civil project, started in 1972 with launch of the ERTS satellite (also known as Landsat1). The LDCM (Landsat Continuity Mission) – Landsat 8 – debuted in 2013, overseen by National Aeronautics and Space Administration (NASA) and USGS, with the scope of acquiring imagery from earth's

surface. The LDCM Satellite has two instruments: OLI (Operational Land Imager) and TIRS (Thermal InfraRed Sensor), which allows for global coverage, at resolutions of 30m (visible spectre, NIR, SWIR), 100m (thermal bands) and 15m (panchromatic band) (Herbei et al., 2015).

The satellite carries the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS) instruments. The OLI measures in the visible, near infrared, and shortwave infrared portions (VNIR, NIR, and SWIR) of the spectrum. The TIRS measures land surface temperature in two thermal bands with a new technology that applies quantum physics to detect heat. Landsat 8 images have 15-meter panchromatic and 30-meter multi-spectral spatial resolutions along a 185 km (115 mi). For the purpose of this paper, we used the ArcGis Desktop software, which also included the following extensions: ArcCatalog, ArcMap and ArcToolbox. Said tools were used in the following steps; we first inserted the map of Romania, and subsequently used the Timiș county as subject of representation for normalized difference indices (Figure 1 and Figure 2).

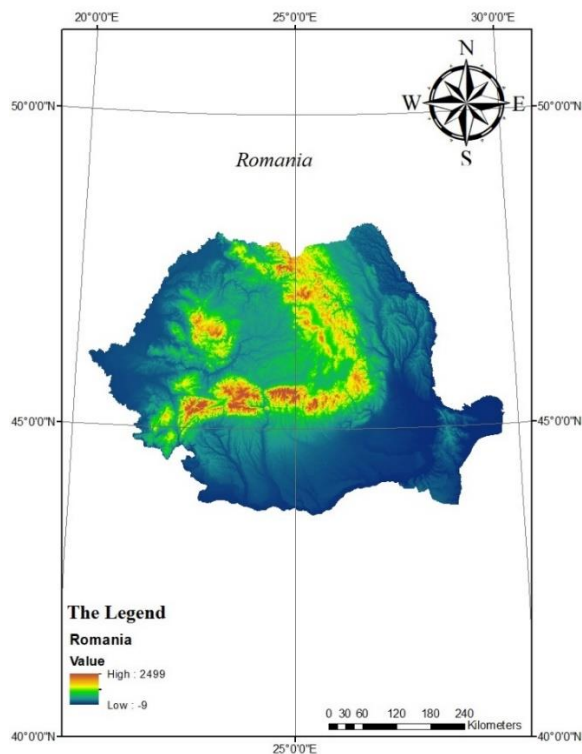


Figure 1. Digital elevation model of Romania

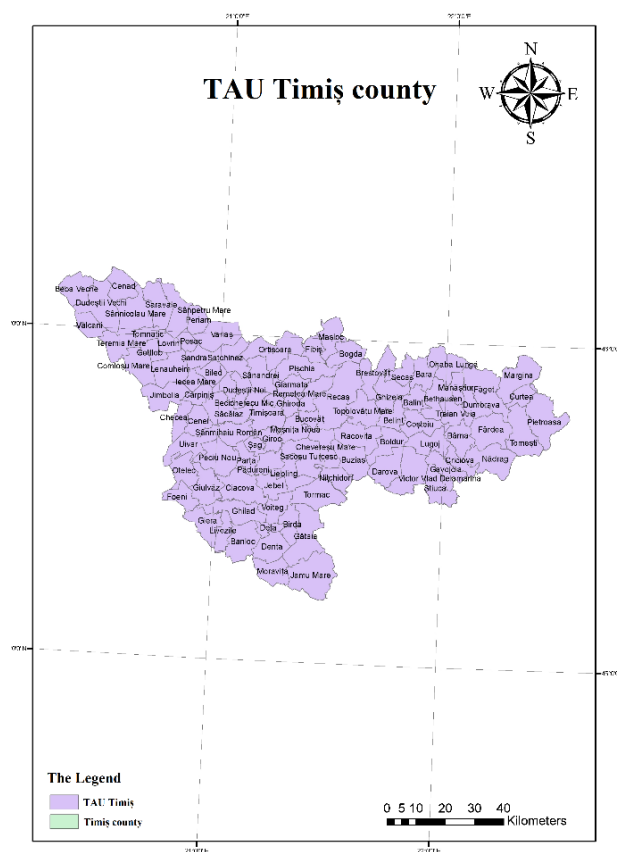


Figure 2. Map of TAU's from Timiș county

Timiș county is located in the western part of Romania, in the centre of the historical province of Banat. Its county seat is the municipality of Timișoara, capital of the western region, and largest city by size and importance in the Romanian southwestern macroregion of development. Timiș County was abolished by Law no. 5 of 8 Sept. 1950 (until then bearing the name Timiș-Torontal, with an area of 7,600 km², 13 towns, two cities – Timișoara and Lipova, and 243 villages) and the Timișoara region was established, with its headquarters. in Timișoara, which in 1956 was transformed into the Banat region (21,800 km², 12 districts, 16 cities and several hundred villages), and by Law no. 2 of February 17, 1968, it became a county again, with a supr. of 8,697 km² (the largest in the country), ten cities (two of which are municipalities), 89 communes and 313 villages. As previously mentioned, we created the maps with the help of ArcGIS Desktop, a software suite produced by Esri. It allows the user to make, workshop and integrate the analysis and display of geographical data at different levels of conceptualization.



Figure 3. Geographic information system

(https://www.google.com/search?q=gis+poze&sxsrf=APwXEdcSGqHncblbzmqjLQ1ThjcUnE UguzQ:1682507792363&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiwqa76tcf-AhWPgf0HHWPNAJEQ_AUoAXoECAEQAw&biw=1536&bih=722&dpr=1.25#imgrc=Ft0dm4EkKJWj9M)

ArcMap is the main component of Esri's ArcGIS suite of geospatial processing programs, and is used primarily to view, edit, create, and analyze geospatial data. ArcMap allows the user to explore data within a data set, symbolize features accordingly, and create maps. This is done through two distinct sections of the program, the table of contents and the data frame. In October 2020, it was announced that there are no plans to release 10.9 in 2021, [2] and that ArcMap would no longer be supported after March 1, 2026. Esri are encouraging their users to transition to ArcGIS Pro.

ArcMap users can create and manipulate data sets to include a variety of information. For example, the maps produced in ArcMap generally include features such as north arrows, scale bars, titles, legends, neat lines, etc. The software package includes a style-set of these features. As well as the ability to upload numerous other reference styles to apply to any mapping function.

RESULTS AND DISCUSSIONS

The normalized difference indices are expressed in the form of new images, in tones of grey, resulting from arithmetic operations taking place between certain spectral bands. In order to visually represent coloured images, red, green, and blue components have to be specified for

each pixel (presupposing a RGB colour scheme). This way, the “value” of the pixel is actually a vector made of three numbers.

The fact that satellite scenes are made up of different spectral bands, acquired in different areas of the electromagnetic spectrum, allow the representation of the components of the physical environment by means of remote sensing indices, respectively images that highlight different aspects related to: vegetation, water, built space, snow cover , etc.

The normalized indices of differentiation of landscape elements, namely vegetation (NDVI), water (NDWI), snow (NDSI), soil moisture (NDMI), etc., have a wide applicability and are used in different aspects, both in theoretical as well as practical level (Kulkarni et al., 2002; Pettorelli et al., 2005; Gu et al., 2007; Loranty et al., 2018; Huang et al., 2021).

The Normalized Difference Vegetation Index - NDVI (Figure 4).

This index was first introduced in the literature by Dr. John Rouse in 1973.

Formula (1) :

$$NDVI = \frac{NIR - R}{NIR + R}$$

At the level of the study area, namely Timiș county, the NDVI values were maximum in the eastern part, in the Poiana Ruscă Mountains area.

The NDVI values may vary depending on the radiation absorbed by the chlorophyll in the red spectral zone and its reflectance in the near-infrared spectral zone. These values are noted between the values of -1 and +1, expressing the consistency of green vegetation. Values close to the +1 range (light tones) represent large-consistency vegetation and are specific for deciduous forests.

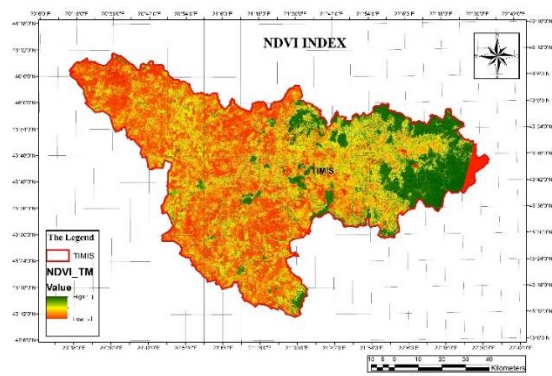


Figure 4. Timiș NDVI map

2. The Normalized Difference Water Index - NDWI (figure 5).

This index was proposed by McFeeters in 1996. Formula (2):

$$NDWI = \frac{NIR - GREEN}{NIR + GREEN}$$

Regarding the NDWI indices, the maximum values were also in the eastern part, being the mountainous area.

This index is used to map aquatic surfaces, as well as differentiate them in terms of turbidity (the content in sediments). When calculating the NDWI, green spectral bands are used (due to electromagnetic radiations piercing the water) as well as near-infrared (increasing the spectral response of the humidity in the soil, rocks and plants; the water begins to absorb the radiation from the uppermost surfaces).

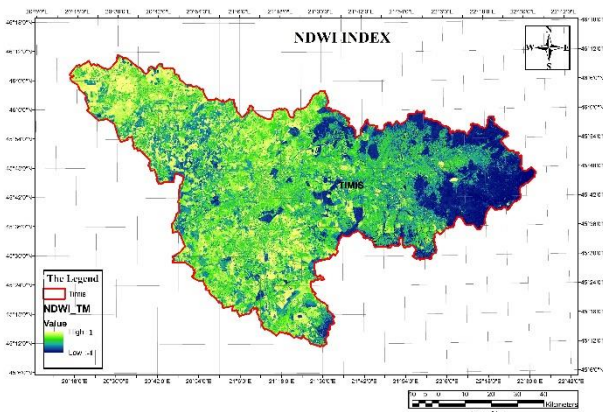


Figure 5. Timis NDWI map

3. The Normalized Difference Snow Index – NDSI (Figure 6). This index was introduced in the literature by Sidjak and Wheate in 1999.

Formula (3) :

$$NDSI = \frac{GREEN - SWIR1}{GREEN + SWIR1}$$

In calculating the formula, green spectral bands are used (in which the reflectance of snow is at its maximum) as well as medium infrared (in which humidity has its greatest reflectance). The values that make up the NDSI produced image range between -1 (dark tones displaying surfaces uncovered by snow) and +1 (light tones symbolizing snow-covered terrain). The white colour of snow is produced by the green band's high reflectance.

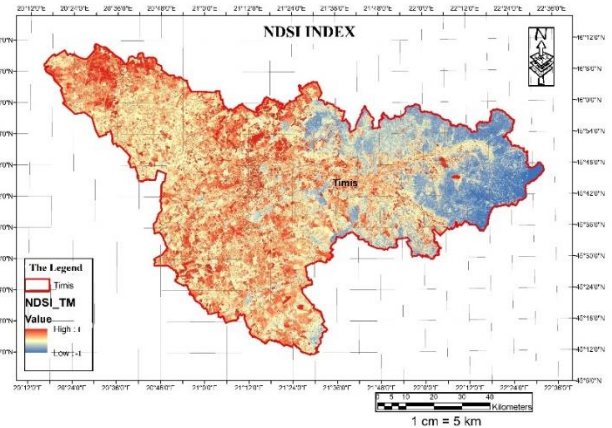


Figure 6. Timis NDSI map

4. Normalized humidity Differentiation Index – NDMI (Figure 7)

Formula (4) :

$$NDMI = \frac{NIR - SWIR1}{NIR + SWIR1}$$

Is reliable when looking at the differentiated highlight of certain objects' humidity content. Here we refer to components from the environment, especially soil, vegetation, or geological formations.

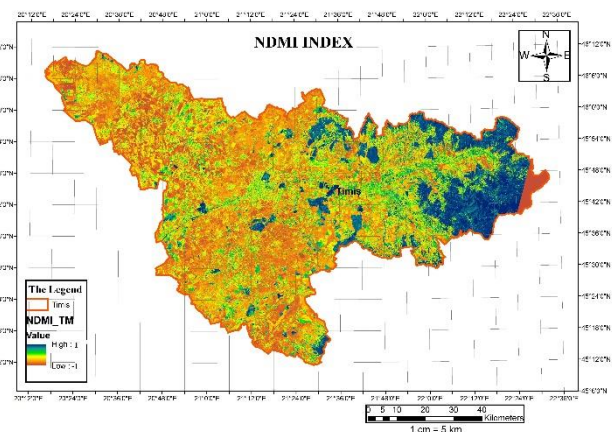


Figure 7. Timis NDMI map

5. The Normalized Difference Burn Ratio – NDBR (Figure 8)

Formula (5) :

$$NDBR = \frac{NIR - SWIR2}{NIR + SWIR2}$$

This index is useful, especially when charting zones with a high potential for ignition (mountainous areas with large forest-covered surfaces where the foehn effect may jump start fires, savannahs, high temperature areas, etc.). To obtain this index, the software used bands in

which the spectral responses of unlit vegetation (near-infrared), as well as as lit vegetation (medium infrared) are the most potent.

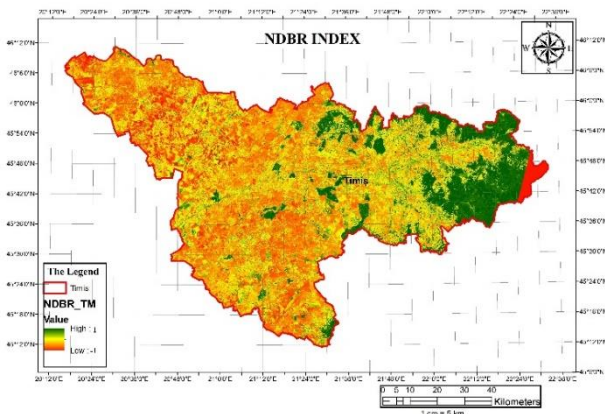


Figure 8. Timis NDBR map

6. The Normalized Difference Built-up Index - NDBI (figure 9) was introduced fairly recently in the literature by Y. Zha in 2003.

Formula (6) :

$$NDBI = \frac{IR - NIR}{IR + NIR}$$

NDBI proves to be useful in territorial analysis, through highlighting the built-up environment (human settlements, road networks, bridges, dams, etc). The NDBI formula includes the spectral signatures of objects from the mid-infrared bands (with great reflectance of humidity, including construction materials) and near-infrared (with maximum reflectance of vegetation).

In other words, it is used for the spectral differentiation of vegetation and construction materials.

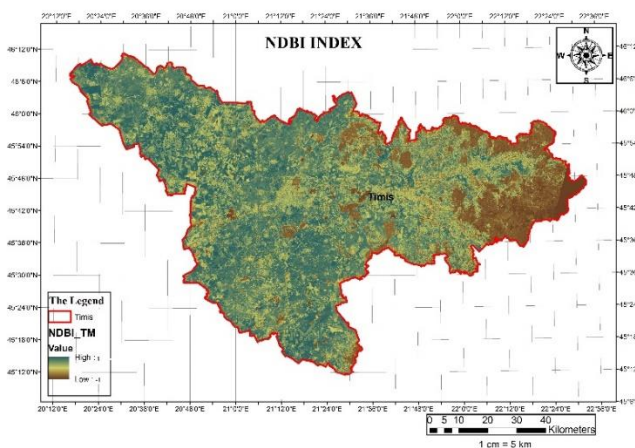


Figure 9. Timis NDBI map

CONCLUSIONS

Landsat 8 spectral bands help us in coastal and aerosol studies, distinguishing soil from vegetation, plant differentiation, soil moisture detection and thermal mapping. Each band can be viewed as a distinct image. The principles used to classify satellite images are based on the analysis and placement of pixels with similar characteristics in the same group. And with the help of the ArcGIS program and the ArcMap application we can explore, edit, analyze and symbolize the data.

The purpose of the research included in this study was to apply different remote sensing indices to highlight, on the one hand, the variability of environmental factors in the territory considered as a case study (Timiș county), and on the other hand, the possibility of analyzing " from a distance" of a vast territory, under different aspects: vegetation, water surfaces, built space, etc.

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- ***-<https://www.usgs.gov/landsat-missions/landsat-8>
- ***-https://ro.wikipedia.org/wiki/Jude%C8%99Bul_Timi%C8%99
- ***-https://www.academia.edu/35368118/GIS_Examples_pdf
- ***-<https://en.wikipedia.org/wiki/ArcMap>
- ***-<https://romaniadategeografice.net/unitati-admin-teritoriale/judete/judete-t/timis/>
- ***-https://www.google.com/search?q=gis+poze&sxsrf=APwXEdcSGqHncblbzmjLQ1ThjcUnEUguzQ:1682507792363&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiwqa76tcf-AhWPgf0HHWPNAJEQ_AUoAXoECAEQAw&biw=1536&bih=722&dpr=1.25#imgrc=Ft0dm4EkKJWj9M

MAPPING MARS: HOW THE CURIOSITY ROVER USES PHOTOGRAMMETRY TO EXPLORE THE RED PLANET

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Abstract

The largest and most capable rover ever sent to Mars, Curiosity is a component of NASA's Mars Science Laboratory program who was launched on November 26, 2011 and landed in Gale Crater on Mars on August 5, 2012. Since landing on Mars, the Curiosity rover has explored the 5 km high Mount Sharp (Aeolis Mons) in Gale Crater, climbed over 612 meters, reaching younger and younger rocks. The Mars Science Laboratory (MSL) team can analyse the sedimentary deposits by using a collection of imagers placed on the rover, that provides generous pixel sizes and multiple fields of view from close to long-range observations. For this examination the ChemCam instrument, which is mounted on the rover mast, uses a Remote Micro-Imager (RMI), that functions as a 700 mm-focal length telescope, and a Laser-Induced Breakdown Spectrometer (LIBS). Up to a few kilometres out from the rover, remote outcrops can be observed with the RMI. According to this study an experiment aimed at computing for the first time with RMI Digital Outcrop Models of these remote outcrops as collecting 3D information is essential to characterizing the architecture of the sedimentary deposits. Therefore it is demonstrated how adequate collections of individual RMI frames may be used to successfully apply Structure-from-Motion photogrammetry to rebuild the 3D shape and relief of these remote outcrops. This article aims to showcase the application of photogrammetry in the exploration of Mars, highlighting the ways in which this technology has been utilized to gather and analyze valuable data about the planet's geological features and atmospheric conditions.

Key words: Curiosity rover, Digital Outcrop Models, MARS Photogrammetry, Structure-from-Motion, 3D.

INTRODUCTION

Photogrammetry is a technique used to measure and analyze physical objects and environments using photographs. It has been widely used in a variety of fields, including surveying, engineering, and archaeology. In recent years, photogrammetry has also become an important tool for studying celestial bodies, such as planets and moons in our solar system.

In this article, we will focus on the use of photogrammetry technology in studying the Martian landscape, specifically with regards to the data collected by the rover Curiosity.

The rover Curiosity has been instrumental in collecting high-quality data about the geology, topography, and atmosphere of Mars. One of the key technologies used by the rover is photogrammetry, which has enabled scientists to create detailed 3D models of the Martian landscape. These models have provided valuable insights into the history and evolution

of the planet, as well as the potential for supporting life.

It is believed that early on, Mars had rivers and large lakes and perhaps even a northern ocean. Since then Mars has experienced dryness, a slow loss of a sizable component of its atmosphere, and the freezing of near-surface water.

The Mars Exploration Program currently has five operating missions at Mars to help understand the climate from past to present, and even future possibilities.

In comparison to past Mars rovers, the Curiosity rover has a payload that is more than 10 times larger and has the most sophisticated scientific equipment ever used on Mars' surface. The 5-km-thick sequence of Mount Sharp (Aeolis Mons), which dominates the Gale crater on Mars, possess a significant portion of sedimentary rocks. It is the location of the Mars Science Laboratory (MSL) rover Curiosity, whose objective is to characterize the geological record using a variety of instruments and look

for signs of previous habitability at a time when liquid water was available on the surface of the red planet. Therefore, a key component of its goal is the team's ability to interpret the multiscale geomorphological and sedimentological traits that are present there to describe the previous ecosystems.

In order to achieve this, the analyses rely on all the imaging tools available on the rover, such as the navigation cameras (Navcam), the color science imagers Mastcam, and the Remote Micro Imager (RMI) subsystem of the ChemCam instrument. The ability to collect multi-scale close-range to faraway observations is made possible by this collection of devices with multi-layered fields of view.

The ability to image on several scales is crucial for characterizing the Martian rock exposures that occur naturally. Despite their scientific importance, several zones are inaccessible to the rover because of its traversal ability concerns and resource/time optimization restrictions. Therefore, the rover's exploration is totally dependent on orbital data and remote imaging from about a hundred meters to several kilometres away utilizing onboard cameras (Mastcam, RMI).

In this study, it is suggested the use of long-range imagery from RMI's telescope to produce Digital Outcrop Models (DOM) of remote outcrops. For this it is necessary to apply Structure-from-Motion photogrammetry, a technique usually performed on close-range geologic features obtained with other imagers onboard the rover (MAHLI, Mastcam, Navcam). Moreover, it is essentially to implement photogrammetric treatment to specific sets of recurrent long-distance RMI observations that were specifically targeted on the sulphate-bearing units.

MATERIALS AND METHODS

About 3.5 to 3.8 billion years ago, during Mars' early history, a meteor struck the planet, creating Gale Crater (Figure 1.a) that is about 155km long. The landscape was pierced by the meteor's impact. Because Gale Crater offers several indications that water has been present throughout its history, scientists selected it as the landing site for Curiosity. The rover landed in the northern part of this crater, in the Aeolis

Palus region. Since then, the rover has traversed a distance of around 25 km while studying the geology of Aeolis Palus and the lower flanks of Mount Sharp (Aeolis Mons) (Figure 1.b,c).

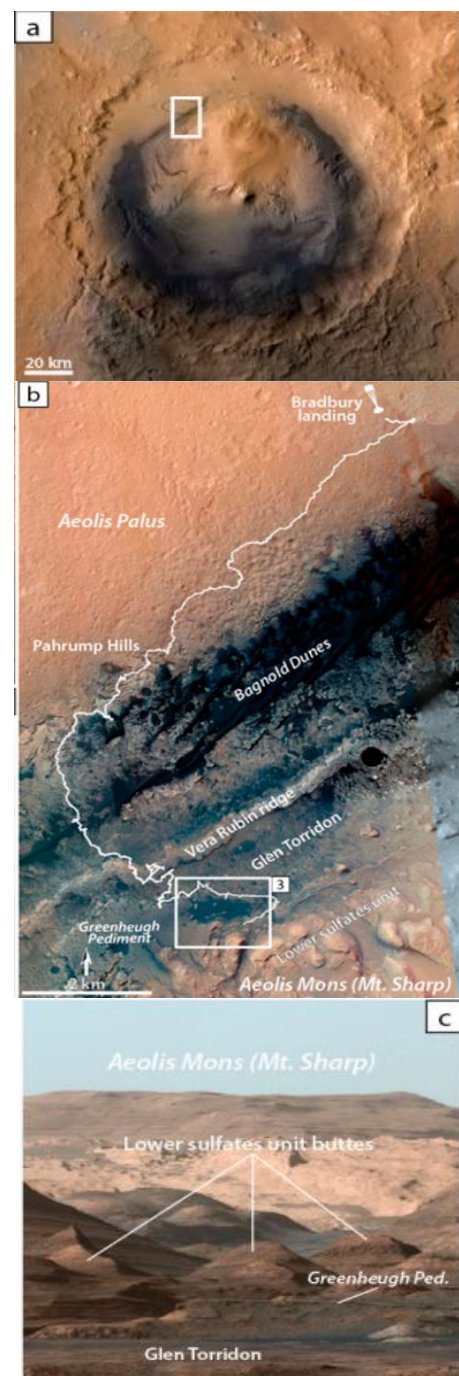


Figure 1. Localization of the studied area on Mars. (a) Orbital image of the Gale crater. The white box represents the area of operations of the Curiosity rover. (b) View of path followed by the rover (white line) since Bradbury landing in August 2012 and up to the lower sulfate unit transition (as of July 2021). (c) Panoramic view from Aeolis Palus showing the vertical succession of the major units in Mount Sharp stratigraphy, notably highlighting the location of Glen Torridon region and the lower sulfates unit. ©NASA Photojournal

The layers in the central mound (Mount Sharp) imply that it is the last surviving fragment of an extended chain of deposits.

According to scientists the crater is filled in with sediments while the continuous Martian winds carved Mount Sharp which now towers 5.5 kilometres above Gale Crater's level and is three times as tall as the Grand Canyon.

This part of the sedimentary pile that has only been characterized by orbital data or by remote long-distance imaging using the onboard cameras on the rover.

The present article is focused on RMI's long-distance observations of the lower sulphate unit outcroppings above the Glen Torridon area, where the rover was located at the time the photos were collected (Figure 1.b,c).

The Curiosity Rover

The rover, which is approximately the size of a MINI Cooper and about as tall as a basketball player, uses a 7 foot-long arm to place tools close to rocks selected for study. These tools include 17 cameras, a laser to vaporize and examine far microscopic pinpoint areas of rocks, and a drill to take samples of the rock's powder. It hunts for special rocks that formed in water and/or have signs of organics components.

A radioisotope power generator from the U.S. Department of Energy provides the rover with electricity. The heat of the radioactive decay of plutonium-238 is converted into energy by the multimission radioisotope thermoelectric generator. The mission can operate on Mars' surface for at least a complete Mars year (687 Earth days) because to its durable power source. The largest and most sophisticated scientific research tools ever dispatched to the surface of Mars are aboard Curiosity. The chemistry and structure of the rocks and soil record the evolution of Martian climatology and geology. By examining powdered samples taken from rock drill holes, Curiosity deciphers this record. In order to ascertain a rock or soil's composition and history, particularly its interactions with water in the past, it also analyses the chemical fingerprints that are present in such materials.

The mission's primary method of communication between Curiosity and the Deep Space Network antennas on Earth is radio relays via Mars orbiters. About 48 terabytes of data

from Curiosity were downlinked by the orbiters in the first two years following its arrival.

It can only communicate with each probe for 8 minutes a day, and signals between Earth and Mars take an average of 14 minutes and 6 seconds. Originally the rover was designed to operate for two years on Mars, instead it continued to operate with success and is still conducting scientific research on the red planet. The previous Mars Pathfinder and Mars Exploration Rover mission operations software serves as the foundation for the Robot Sequencing and Visualization Program (RSVP) for the Mars Science Laboratory Mission (MSL). The RSVP consists of two main tools:

1. The Robot Sequence Editor (RoSE) effectively supports every command in the mission dictionary through the use of a graphical user interface (GUI). RoSE also communicates with the JPL spacecraft sequence generation system (SEQGEN) and rp-check for resource calculations and sequence validation, as well as Surface Flight Software Simulation (SSim) and HyperDrive to simulate the execution of arm, turret, and driving instructions. All drive, arm, and turret command sequences delivered to Curiosity are created using RoSE.
2. HyperDrive provides a range of 3D graphics interfaces to enable the visualization of stereo images and 3D terrain-model data collected from Mars. This software is used to plan all of the rover's movements, from traversing the Martian surface to maneuvering the robotic arm and turret to position equipment at sites of geological interest.

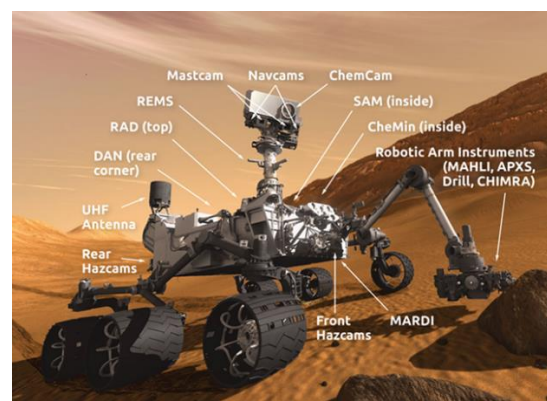


Figure 2. Instruments on board the Curiosity Rover

Instruments on board the Curiosity Rover

Curiosity is equipped with 17 instruments serving multiple purposes such as cameras: Mastcam, MAHLI, MARDI, spectrometers: APXS, ChemCam, ChemMin, SAM, radiation detectors: RAD, DAN, environmental sensors: REMS, navigation cameras: Navcam, Hazcam and atmospheric sensors: MEDLI.

The most significant instruments onboard the rover are the five cameras situated on the 2m high Remote Sensing Mast (RSM): the Navcam pair, the Mastcam pair and the ChemCam's RMI (Figure 3.a).

The two pairs of Engineering Navigation Cameras (Navcams) (Figure 3.b; Table.1) are a visible light-based, black-and-white cameras that captures panoramic, three-dimensional (3D) images. Scientists and engineers can simulate ground navigation using the stereo pair of cameras in the navigation camera unit. Each camera has a 45-degree field of view. By offering an additional perspective of the ground, they enhance the danger avoidance cameras' job. The Mast Camera (Figure 3.b; Table.1), which has a powerful zoom lens, captures color photographs, three-dimensional stereo photos, and color video recordings of the martian landscape. The Mars Science Laboratory rover deck supports a mast that extends upward, holding two identical camera systems positioned on it. Similar to how the human eyes work, the cameras combine two side-by-side pictures acquired from slightly different orientations to create three-dimensional stereo views. These cameras may be utilized to generate stereo mosaics or even 3D DOM but, in comparison to the Navcam pair, their unique focus length results in a smaller field of 3D data capture.

The Chemistry and Camera (ChemCam) mechanism package incorporates two remote sensing instruments: the first planetary science Laser-Induced Breakdown Spectrometer (LIBS) and a Remote Micro-Imager (RMI). The RMI sub-system of the ChemCam instrument's main assignment is to image the targets subjected to Laser-Induced Breakdown Spectrometry analysis. This enables up-close examinations of the examined rock's texture and the laser-shot marks left afterward. While the RMI was not originally designed for long-distance observation, its 700 mm focal length has proven

to be advantageous for directing the telescope at distant objects.

The RMI is capable of producing highly accurate greyscale images of outcrops located several kilometers away. The RMI offers a complementary imaging feature of the distant geological features with a very high resolution, but with a limited field of view, since its pixel size is 3.7 smaller than that of the M-100. The region captured by a composite RMI mosaic created from two merged observations (15x3 and 10x3 mosaics) is highlighted by the white box in the color Mastcam mosaic of Figure 3c (top panel). RMI makes it possible to observe additional elements that were not identifiable on the Mastcam picture, such as meter-scale cross-stratifications and individual blocks indicated in the detail boxes at the bottom of Figure 3c. This ability is essential for characterizing features on distant outcrops or those that are inaccessible to the rover. However, the RMI is not inherently capable of creating stereo-images to offer a 3D picture of the observed outcrops, unlike the Navcam and Mastcam pairs.

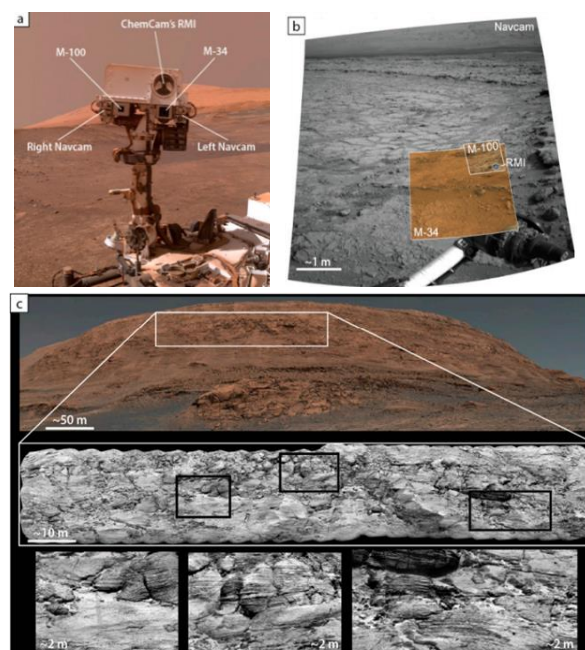


Figure 3. (a) Detail of a "selfie" picture of Curiosity taken on sol 1943 by the MAHLI camera, showing the Remote Sensing Mast of the rover and the position of its main imaging instruments: Navcam, Mastcam and RMI (base image PIA22207); (b) Composite image showing the variations in resolution, color, and field of view of the different Navcam, Mastcam and RMI imagers (images

CR0_412749646PRC_F0060000CCAM02171L1,
0198MR0010070380202807E01,
0170ML0009050660104745E01,

NLA_412415874EDR_F0060000NCAM12754M1); (c)

Upper part: Mastcam (M-34) color mosaic of a large butte in the lower sulfates unit (Mastcam image sol03154_ML_100270); Lower part: composite RMI mosaic (images ccam3151 and ccam4153) corresponding to the white box in the Mastcam mosaic. RMI shows a higher level of details, allowing to distinguish down to meter-scale cross-stratifications and individual blocks (bottom detail boxes) from several hundred meters. ©NASA Photojournal.

By combining the colour information from Mastcam-100 photos with the high spatial resolution greyscale RMI images, an integrated output is created that can be used to understand the variety of LIBS signatures present in a particular raster. After merging the two images, color information from Mastcam can be added to the RMI image using a pansharpening algorithm in cases where targets are observed simultaneously by the RMI and M-100.

At the John Klein location in Yellowknife Bay, both cameras captured drill cuttings on Sol 183, as shown in Figure 4. Investigating the drill tailings' heterogeneity was the aim of this observation.

Figure 4.a displays a full-frame M-100 image with white circles denoting the footprints of the four RMI photos displayed on the right. The M-100 picture in the overlapped region is shown in Figure 4.b. Also Figure 4.c. is a mosaic of the four RMI photographs that represents the results of the LIBS analysis in the specific area. The positions of the individual LIBS measurements are shown by red arrows. Using the ESRI pansharpening algorithm integrated into the ArcGIS program, Figure 4.d combines RMI with the color data captured by M-100.

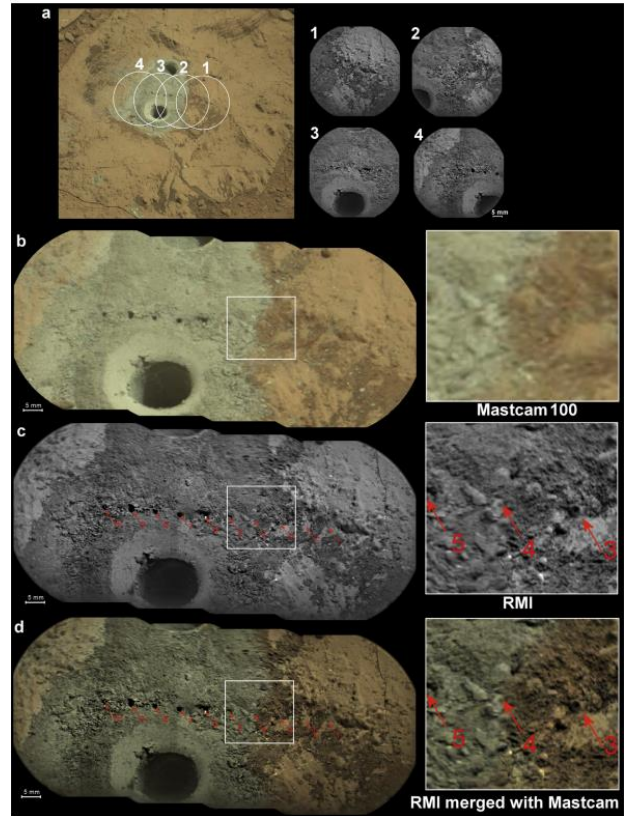


Figure 4. Example of RMI-Mastcam color fusion on the drill tailings observed from a distance of 2.46 m during Sol 183 at John Klein site in Yellowknife Bay. (a) M-100 image 0183MR0009930070202041E01 (left) and RMI images (right)

CR0_413737102EDR_F0060000CCAM02183M1,
CR0_413737471EDR_F0060000CCAM02183M1,
CR0_413737840EDR_F0060000CCAM02183M1 and
CR0_413738369EDR_F0060000CCAM02183M1.

(b) Portion of M-100. (c) RMI post-LIBS mosaic. (d) RMI mosaic merged with M-100 using pansharpening. The white rectangle corresponds to the insets on the right, illustrating the benefits of merging the two datasets

Table 1. Main optical parameters of the Navcam, Mastcam and RMI imagers onboard Curiosity.

Instrument	Common Designation	Colorization	Resolution	Focal Length
Navigation Cameras	Navcam	Greyscale	1024 × 1024 px	14.67 mm
Mast Camera(left)	Mastcam left(M-34)	RGB	1600 × 1200 px	34 mm
Mast Camera(right)	Mastcam right(M-100)	RGB	1600 × 1200 px	99.9 mm
Remote Micro Imager	RMI	Greyscale	1024 × 1024 px	700 mm

RESULTS AND DISCUSSIONS

Digital Outcrop Modelling (DOM) - Structure from Motion for generating DOM

An outcrop is a part or area of rock that appears or emerges at the surface of the terrain. To define and comprehend the circumstances leading to the creation and/or change of a geological outcrop, 3D information might be significant. This is especially true in the case of the detrital depositional record found in Gale crater and the discovery of structures caused by sedimentary processes. Nevertheless, when examining Martian outcrops from orbit and/or from rover-derived data, this 3D information is not easily accessible. One way to make up for the inability to see these characteristics "in person" is to digitally reconstruct the 3D geometry of the investigated outcrops using the data the rover collected.

Structure from motion (SfM) is a photogrammetric range imaging technique that can estimate 3D structures from 2D picture sequences that might be combined with local motion data by overlapping. This method can be used to generate these DOMs.

SfM photogrammetry is frequently used on Earth and in the planetary community and is especially well suited for geological investigations. Using Navcam, MAHLI, Mastcam, or a combination of these sensors, numerous effective examples of DOM reconstruction to define the sedimentary record have been successfully achieved in the case of the Gale crater.

The current study shows how this technique is applied to images provided by the RMI telescope, in order to restructure the 3D shape of remote and unattainable outcrops that are several hundreds of meters away from the rover. For the SfM procedure it was used the commercial Agisoft Metashape Professional software v.1.7.1 (Agisoft LLC, St. Petersburg, Russia).

Using information from the Mars Hand Lens Imager (MAHLI), it was possible to rebuild item models at the millimetre scale and create landscape models at the decimetre scale. Additionally, it was pointed out that information about the camera's position and attitude is a by-product of the SfM model construction.

There were given some suggestions for uses of SfM for this purpose in present and future planetary exploration missions using this capability to illustrate reconstruction of Curiosity's traverse path from pictures alone.

The input images must have a high enough quality for the program to detect material similarities between several photographs in order to get the best results.

For optimal model reconstruction and to maximize the number of key points connected across the photoset, sufficient overlap is also required.

Small-Scale SfM Object Models

To obtain small-scale SfM Object Models, MAHLI camera, which is a 1600x1200 pixel color camera attached to the robotic arm of Curiosity, can be used because of its capacity of micro-imaging of rocks and outcrops.

At its greatest resolution, MAHLI can produce images with a resolution of 13.9 m/pixel from a range of 2.04 cm. MAHLI is the perfect instrument for SfM imaging since it can gather images from many angles pointed at a single subject.

A 3D model of the Bimbe aggregate that was created from a collection of 9 photos taken by MAHLI on sol 1409 is shown in Figure 5. The model is scaled at 45 mm across.

MAHLI is able to capture stereo pair images and the vertical inaccuracy of the relief is being researched. Stereoscopy should be compared to SfM modelling as a substitute.

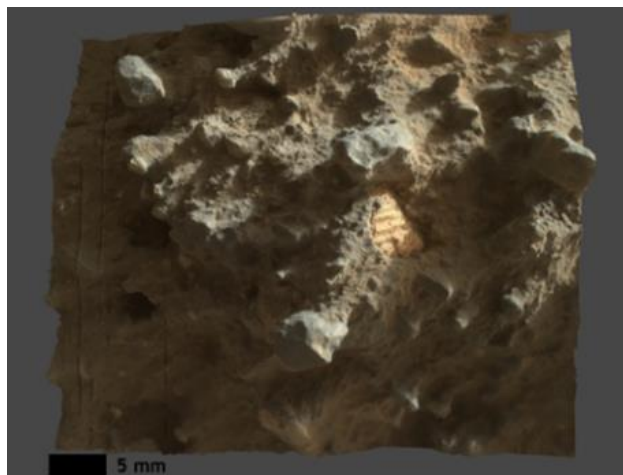


Figure 5. Bimbe conglomerate reconstructed using Agisoft Photoscan Professional from Curiosity MAHLI images taken on sol 1409.

Large-Scale SfM Terrain Models

Additionally, to create large-scale SfM Terrain Models, the Navcam onboard Curiosity is a better fitted option since it has the capability of simultaneously photographing the surrounding environment with enough overlap and parallax to create models with detail at a close range to the rover.

Also 3D terrain model of the Murray Buttes was developed from a collection of 25 Navcam pictures from sol 1455 is illustrated in Figure 6. With increasing distance from the rover, there are gaps in the model and insufficient overlap between photos, loss of photo resolution, and depth of field.

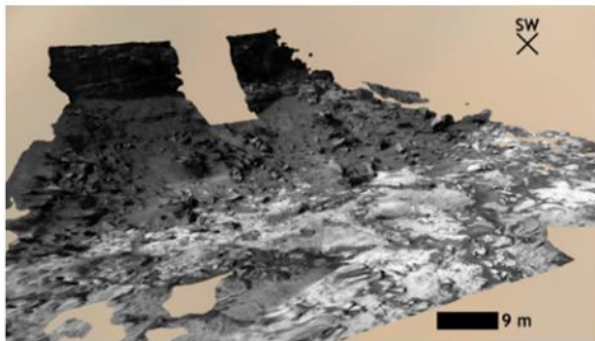


Figure 6. Murray Buttes reconstructed using Agisoft Photoscan Professional from Curiosity Navcam images taken on sol 1455.

Traverse Reconstruction

Traverse Reconstruction can be accomplished with the SfM method due to its capacity of calculating original camera position from key point connections. The Curiosity's traverse (Figure 7) was reconstructed for sols 692-703 using 210 images acquired from the Navcams resulting in a model assembled from photosets taken on five different sols (692, 695, 696, 702, 703) (Figure 7.a), that is similar to the actual traverse map (Figure 7.b). In order to enhance the quality of the resulting SfM model, future work will investigate utilizing the size of the rover wheels and their tracks to construct a scale. From previous experiment it was demonstrated that images captured by the rover's onboard cameras may be used to estimate its location if there is enough overlap and image quality. Therefore, camera reconstruction can replace or supplement inertial measurements as a low-cost positional redundancy.

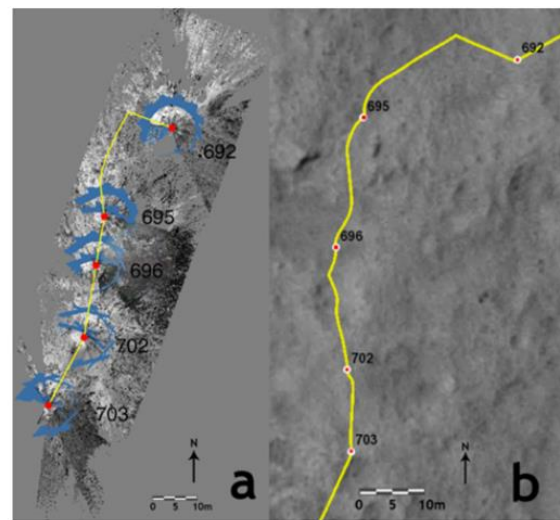


Figure 7. (a) Reconstructed traverse path (yellow) of Curiosity as determined using Agisoft Photoscan Professional and Navcam images from sols 692, 695, 696, 702, and 703. Red points show estimated rover position on these sols and blue polygons denote estimated camera poses. (b) Actual traverse map for Curiosity for sols 692-703.

The Case Study of Reconstruction of Distant Sulfates Unit DOMs

The proposed mesh is a 3D reconstruction of a region photographed by the RMI targets LD_Sulfates_2947b and LD_Sulfates_2962a (Table 2, Figure 8.a), which exhibits a blocky outcrop of cross-stratified lower sulphate unit sandstones that have likely undergone significant diagenetic events. A virtual baseline of around 200 m separated the two points of view from which 41 aligned photos (out of a total of 43, or 95%) were used to rebuild the DOM. From a dense cloud of 2,264,005 points, a mesh of 452,976 polygons is generated as an outcome (Figure 8.b). The shaded model in Figure 7.b shows how successfully the 3D mesh reconstructs the outcrop's blocky expression.

Table 2. List of targets used to compute 3D DOM of remote outcrops and associated data.

Mesh	Target	SeqID	Type	Sol Taken	Dist. From Rover	Virtual Baseline
	LD_Sulfates_2947b	ccam04 947	12 x1	294 7	~650 m	~200 m
	LD_Sulfates_2962a	ccam04 962	16 x2	296 4	~510 m	

Eight tiles of 4096 x 4096 pixel are used to texture the model (Figure 8.c). By visually comparing and choosing GCPs against scaled and calibrated original 2D RMI and Mastcam

mosaics (whose scale is derived as a function of the pixel size and distance to the outcrop), the resultant mesh has been scaled. In order to further restrict the area coverage, we additionally used the orbital HiRISE orthoimage, which produced an error with a sub-metric size, comparable to what is detected in 2D mosaics. The generated mesh, “Long-distance 3D reconstructions using photogrammetry with Curiosity’s ChemCam Remote Micro-Imager in Gale crater (Mars is viewable the study of Caravaca G. (2021).

Sub-metric cross-stratification is extremely common on the outcrop and is unaffected by the various deflation surfaces, as can be seen from the model’s 3D reconstruction. The orange arrows in Figure 8.d,e show some arcuate lineations that emerge out of some blocks as additional structures in this location.

The spatial distribution of these characteristics can be seen in this case thanks to the 3D mesh representation, and they appear to crosscut the outcrop’s overall apparent stratal pattern. These formations might be understood as mineral veins that are most likely diagenetic in origin.

A more in-depth look at the outcrop’s topographic expression in 3D enables the viewer to recognize it’s possible that a contact that is barely visible on the mosaic extends farther to the left. In fact, the contact seen at the base of the outcrop’s right portion is clearly visible at the base of the largest blocks (right Figure 8.a,d).

However, in the more damaged area on the left, it is more challenging to evaluate its continuity. Even so, the 3D mesh allows us to perceive a topographic “step” in this rubbler portion (as seen in differential shading in Figure 8.b), allowing the spectator to follow the continuity of this contact all the way to the model’s boundaries (red line in Figure 8.d).

Even with high-quality 2D imaging, it may be challenging to identify the 3D form of the sedimentary structures in the Gale crater, despite their importance for understanding sedimentary processes. Recently, high-resolution DOM of numerous places explored by Curiosity have been proposed using SfM photogrammetry, but they only apply to outcrops that the rover has “physically” visited. Many remote locations have limited 3D data because they are inaccessible or have not yet been accessed by the rover.

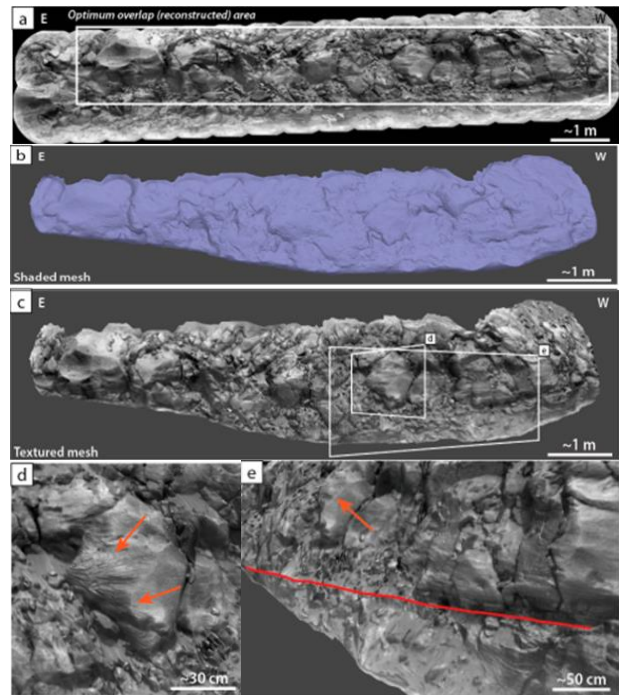


Figure 8. Mesh #1, DOM for the target LD_Sulfates_2962a. (a) Original RMI mosaic (LD_Sulfates_2962a, ccam04962). The white box indicates the optimum overlap with associated mosaic LD_Sulfates_2947. (b) Resulting 3D mesh in shaded view, highlighting the surface relief. (c) Same view with a photorealistic texture applied. (d) Detail on a specific block reconstructed in the DOM. Orange arrows highlight the presence and distribution of probable diagenetic mineral veins. (e) Detail on the lower right part of the DOM, highlighting a topographic step (red line) corresponding to a possible continuation of the sharp contact between two sedimentary beds. The orange arrow also points to features illustrated in (d).

However, this 3D data might be essential in characterizing the sedimentary record viewed from a distance with greater accuracy and detail than in typical orbital digital elevation models. Therefore, in this study, it was investigated whether it was possible to recreate the 3D geometry of a remote outcrop using distant photos captured by Curiosity’s RMI telescope. RMI is the most potent imager in terms of pixel size, despite not being created with long distance stereo imaging in mind.

CONCLUSIONS

In this study we illustrated the benefits provided by the use of photogrammetry and its derived products such as DOMs to better understand, evaluate and organize further research on Mars.

Structure-from-Motion photogrammetry, which is carried out by the Metashape program, can be utilized to successfully compute the DOMs of these distant outcrops using individual frames from overlapping long-distance RMI mosaics.

The models that are created as an outcome of computing these RMI mosaics allow analysis of the overall precise 3D form of the geologic objects that are outside of the rover's reach. The science team will be able to characterize, for example, the distant sulfates unit of Mount Sharp, a key-objective of the MSL mission, with the assistance of this new, powerful, and original method of characterizing the 3D geological record remotely observed from several hundred meters, in combination with existing imagery such as Mastcam (stereo-)mosaics and typical RMI mosaics.

To optimize the science result and identify high-interest locations in advance, it may be helpful to organize the upcoming exploration of this sulfates period before the arrival of the rover on site by calculating a DOM remotely using RMI. The photogrammetry data collected by the rover Curiosity has allowed researchers to study the Martian landscape in unprecedented detail. By analyzing the 3D models of the Gale Crater and other regions of Mars, scientists have been able to identify and analyze the layers of rock that make up the planet's surface. This has enabled them to reconstruct the history of Mars and understand how the planet's environment has changed over time.

In conclusion, the use of photogrammetry technology has been instrumental in advancing our understanding of the Martian landscape, and has provided valuable insights into the history and evolution of the planet. The data collected by the rover Curiosity has enabled scientists to create detailed 3D models of the Martian surface, which have been used to study the geology, topography, and atmosphere of the planet.

The photogrammetry data has also provided important information about the potential for supporting life on Mars. By analyzing the mineralogy and chemistry of the rocks and soil, scientists have been able to determine the presence of key elements and compounds that could be used for sustaining human life on the planet. This information is crucial for planning future missions to Mars, and could ultimately

pave the way for human colonization of the planet.

Furthermore, the use of photogrammetry technology on Mars has demonstrated the potential for using similar techniques in the study of other celestial bodies in our solar system and beyond. As our understanding of photogrammetry technology advances, it is likely that we will continue to uncover new insights into the universe around us.

Overall, the use of photogrammetry technology in the study of Mars has been a remarkable achievement, and has provided a wealth of valuable data that will continue to be analyzed and studied for years to come.

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NASA Science – Mars Exploration

<https://mars.nasa.gov/msl/home/>

USING MODERN INFORMATIONAL TECHNIQUES FOR THE ELABORATION OF CADASTRAL DOCUMENTATION

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Abstract

This paper aims to highlight a number of facilities that an engineer in topography can use to automate the elaboration of cadastral documentations. Once the legislation in this field changed, new challenges appeared related to the fast and correct generation of all appendices which are part of any type of documentation. For the proper completion of appendices 13, 14 and 15 all opportunities offered by the Microsoft Excel and Microsoft Word. With regard to appendix 16, the AutoCAD and ArcMap programs were used, with full automation being achieved. VBA code sequences were developed to extras neighbouring parcels from the E-Terra platform and label the arcs with their names. These neighbouring parcels were also analysed in an individual manner with regards to area overlaps. Finally, the whole documentation was completed in an Excel registry, which was afterwards exported into the .pdf format. Testing of this method on 38 cases lead to an eight-fold increase in terms of time efficiency for the completion of cadastral documentations.

Key words: ArcGIS, AutoCAD, automation, cadastral documentation.

INTRODUCTION

This paper, although it has a pronounced applicative character, is still based on concrete data and presents a series of data about an easy method of completing a cadastral documentation. As it is already known, on 08.02.2023 Order no. 600 was published, which approved the Reglementation for receiving and notation of cadastral and real estate records. For most cadastral documentations, certain appendices with attribute data (no. 13, 14 and 15) and both graphical and attribute data (appendix 16) have to be completed.

In order to improve the efficiency of generating these appendices, various software packages have been developed which try to solve the most important issues regarding the graphical pieces (automatic calculation of parcel area, automatic dimensioning etc.) (Tereșneu and Vasilescu, 2013; Tereșneu et al., 2009, 2013). In this case we aim to highlight a method thru which the whole cadastral documentation is automatically completed. All these programs help in various

steps and considerably improve the efficiency with which various appendices are created.

MATERIALS AND METHODS

In order to accomplish the paper's aim, the following were used:

- One laptop Dell Latitude 5411 with a procesor Intel(R) Core(TM) i7-10850H CPU @ 2.70GHz 2.71 GHz; și 16MB RAM;
- Microsoft Office (specifically the Excel and Word packages);
- AutoCAD Civil 3D software;
- ArcMap software
- The result of 38 land surveys, corresponding to 38 parcels.

With regards to research methods, we specify that GIS and other methods belonging to informatics were used in order to automate the whole process of creating a cadastral documentation

parcel boundary for which the cadastral documentation is created, by taking the coordinates of neighbouring parcels as long as these are inside the tolerance admitted by ANCPI for intra-urban/extraurban areas; Automatic extraction of cadastral numbers for registered neighbouring land parcels.

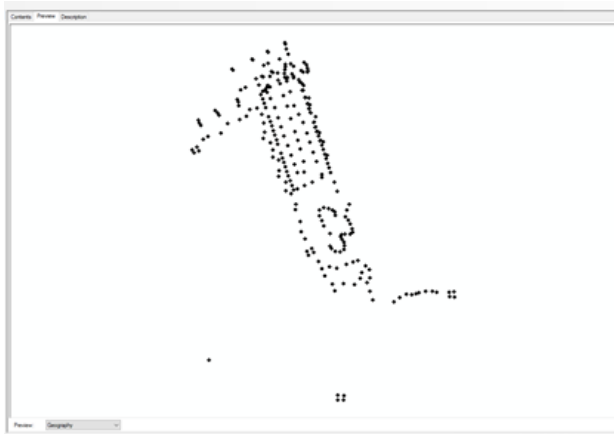


Figure 6. Importing points in ArcMap

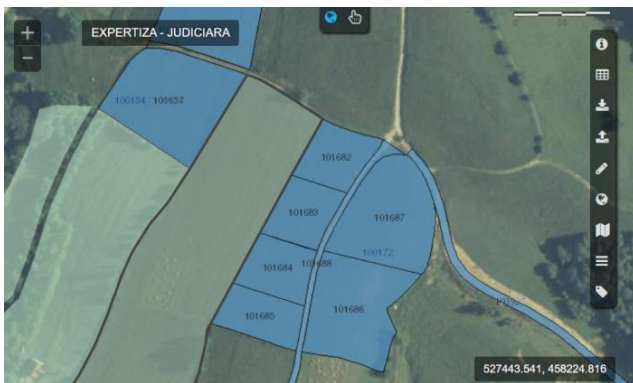


Figure 7. Checking for potential overlaps

All these operations are automatic and make use of the VBA facilities in ArcMap.

The next step is the creation of appendix 16. For this, a new page in A3 format is created in Excel and the general tables specific to this appendix (Figure 8) are inserted, which will then be automatically filled-in from data input into the first page. Then, the complete PAD will be extracted from ArcMap, also by using a VBA script (Figure 9).

The final step is the creation of another Excel page which contains the whole documentation, with appendices 13, 14, 15 and 16 arranged in order. Here a final check of the documentation is carried out and, if everything is in order, a .pdf file is generated for upload to the E-Terra platform. The only thing remaining to be manually input is the contract number and date

in appendix 13 and certain specific mentions which are necessary for the technical report (appendix no. 15).

Nr. cadastral	Suprafața măsurată a imobilului (mp)	Adresa imobilului	
xxxxxx	xxxxxx mp	Loc. XXXXX, str. XXXXX	
Nr. Cartea Funciară		Unitatea Administrativ Teritorială (UAT)	
xxxxxx		xxxxxx	
A. Date referitoare la teren			
Nr. parcelă	Categorie de folosință	Suprafața (mp)	Mențiuni
1	xxxxx	xxxxxx	Teren neîmprejmuit
Total		xxxxxx	-
B. Date referitoare la construcții			
Cod	Destinația	Suprafața construită la sol (mp)	Mențiuni
C1	XXXX	XXXX	Casa xxxxx, construita în anul xxxx; supraf. Desfasurata= xxx mp
Total			-
Suprafața totală măsurată a imobilului = xxxx mp			
Suprafața din act = xxxx mp			
Executant xxxxxxxxx		Inspector	
Autorizat ANCPI, categoriile B-C, seria BV, nr. 231			
Confirm executarea măsurătorilor la teren, corectitudinea întocmirii documentației cadastrale și corespondența acestora cu realitatea din teren		Confirm introducerea imobilului în baza de date integrată și atribuirea numărului cadastral	

Figure 8. Completion of appendix no. 16

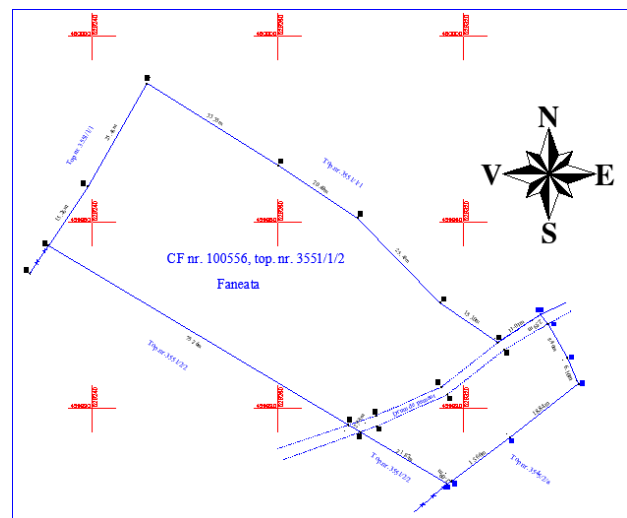


Figure 9. Graphical section of appendix no. 16

This method was tested on 38 cadastral documentation and a considerably improved efficiency was noticed, as the time necessary for the completion of a documentation was between 5 and 8 times lower

CONCLUSIONS

The very high speed with which everything taken place in everyday life implies that the methods for completion of a cadastral documentation must be improved. Steps towards this were and are still being taken, but these only

involve the graphical part of the documentation and just parts of it. In order to achieve maximum efficiency we recommend this method by which Microsoft Excel is used for completion of the written appendices (13, 14 and 15 in the cadastral documentation) and ArcMap is used for the automatic generation of appendix no. 16 (plan of delimitation). Finally, the whole documentation is assembled in a new Excel worksheet, from which a .pdf file is generated. Testing on 38 actual use cases has proven that this method is efficient and deserves to be utilised.

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REALIZATION OF TOPOGRAPHIC WORKS FOR UPDATING THE FORESTRY MANAGEMENT PLAN IN THE LOCALITY OF DRINOVA, TIMIȘ COUNTY

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Abstract

This work is a forest management work that aims to develop the cartographic base of the forestry fund, the public property of the state, administered by the Timiș Forestry Directorate, through the Lugoj Forest District, in compliance with the forestry regime. In this work is presented only the production unit III Drinova within the Lugoj Forest District. In order to achieve the topographic elevations of the limits of the forest bodies, a GPS was used using the RTK method, and for the processing and preparation of the cartographic documentation for the thematic digital maps, was used the computer environment Autodesk Raster design. In order to determine the areas and create the production unit maps, there were used the returned aerophotogrammetric plans with level curves at a scale of 1:5000 for the entire area of 12185.39 ha, corrected with recent orthophotoplans and measurements executed with GPS technology.

Key words: Forest management plan, production unit, cartographic base

INTRODUCTION

The Forest Management Plan is the basic document in forest management, with technical-organizational and economic content, ecologically based (<https://derevoproiect.ro/amenajamente-silvice>).

The management plans are elaborated for the entire forest fund, regardless of the form of ownership: public or private and regardless of the form of administration: state forest districts or private forest districts. The arrangements are valid for 10 years (<https://tehnosilv.ro/servicii/amenajareapadurilor/>).

The Lugoj Forestry District, a subunit of the Timiș Forestry Directorate, has as its object of activity the application of the strategy of the National Directorate of Forests - Romsilva for the forests received under administration, the conservation and sustainable development of the forest fund that is the public property of the state, the management of the hunting and fishing funds assigned according to the law, the

harvesting and valorization of specific forest products according to the legal provisions under conditions of economic efficiency, also exercising public service attributions with specific forestry.

The use of satellite systems from a topographical point of view. Digitalization of plans from analog system to digital system.

MATERIALS AND METHODS

The methods used to carry out the work are GPS and AutoCad. To carry out the GPS measurements, the following operations were carried out: planning and designing the kinematic measurements, performing the kinematic measurements, processing the kinematic measurements. In the case of kinematic measurements, some of the principles of static measurements are valid. The fundamental condition that must be respected in the case of kinematic measurements is the permanent reception of the signals emitted by at least four satellites, both during the stationing

and during the time intervals in which the movement is made from one station to another. AutoCad was used to process the data collected from the field, but also AutoCad RasterDesign. (<https://ro.scribd.com/doc/269444014/rtk>)

RESULTS AND DISCUSSIONS

1. Neighborhoods. Limits. Borders.

The borders are highlighted and materialized with signs frequently used to delimit the forest fund, but also with border milestone.

The limits of the state-owned forest fund are made with conventional signs, applied to the border trees and through milestone.

Within the territorial limits of the production unit in the study, the state-owned forest fund bordering with the forest fund owned by legal entities, individuals, with pastures and hayfields owned by local residents from the neighbouring villages.

The borders are represented by the tree line, being materialized by limit parcel signs, by the production unit or by the detour (executed with red paint on the limit trees) and milestone. The limits with the forest fund belonging to other holders, are materialized in the field, on the limit trees (Forest Management Plan Lugoș Forest Management, 2021).

Table 1. Neighborhoods. Limits. Borders.

Cardinal Points	Neighborhoods	Limits		Borders
		Sorts	Name	
North	U.P.II Valea Lungă	artificial	DC125i intersection 681C-Pogănești-Barna	Tree lines and milestones
		artificial	DJ681C Barna-Săceni	
	O.S Făget	artificial	DC122 Săceni-Surducu Mic	
		artificial	DJ681A Surducu Mic-Fârdea	
East	O.S Făget	natural	Surducului Peak	
		natural	Făgetului Peak	
South	O.S Ana-Lugoșana	natural	Crivinei Peak	
West	U.P. I Tapia	natural	Criciovei Peak	
		natural	Smida Hill	

2. The constitution and materialization of the parcel and under-parcel.

The parcel limits are mostly natural, thus having clear relief forms, waters or tree lines in the case of isolated parcels. The intersections of parcel lines with the limit of the forest fund, at the intersections of the parcel lines between them and at the main contour points, tree lines were placed (Rucăreanu, 2007).



Figure 1. Conventional sign for the parcel



Figure 2. Conventional sign for the under-parcel

As a result of the measurements made on the parcel limits materialized in the field and their transposition on the basic topographical plans, it was found that, in some situations, the limit materialized in the field does not correspond to the existing one on the development plan.

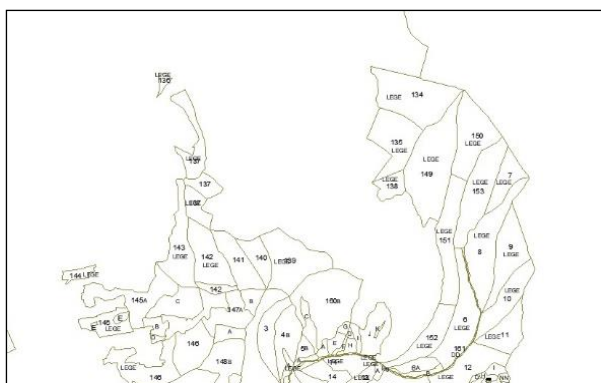


Figure 3. Parcel plan part 1

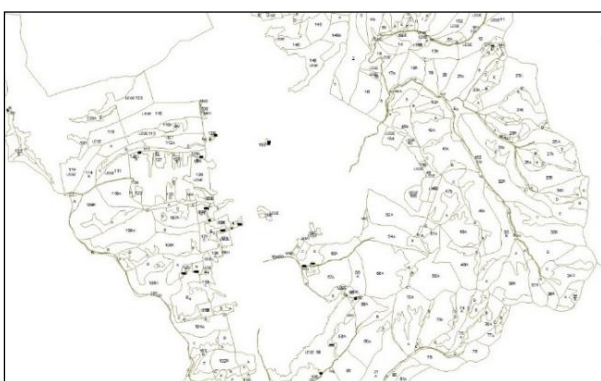


Figure 4. Parcel plan part 2

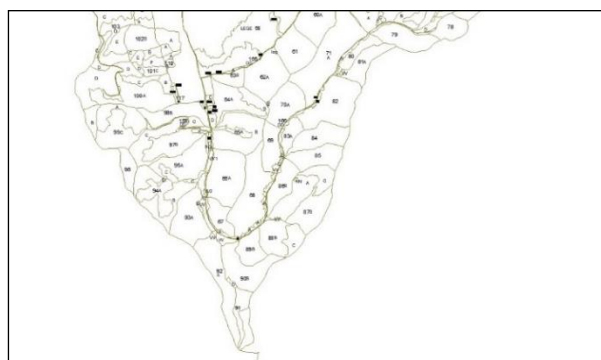


Figure 5. Parcel plan part 3

320, 323, 324, 341, 342, 11bis, 13bis, 27bis, 33bis, 34bis, 41bis, 46bis, 48bis, 50bis, 55bis, 77bis, 114bis, 122bis, 124bis, 128bis, 137bis, 158bis, 164bis, 168bis, 199bis, 205bis, 206bis, 220bis, 223bis, 229bis, 230bis, 232bis, 233bis, 242bis, 245bis, 249bis, 282bis, 284bis, 302bis, 303bis, 312bis, 314bis, 308bis-310bis, 317bis and 320bis.



Figure 6. Milestone



Figure 7. Milestone



Figure 8. Milestone

When correcting the parcel limits on the topographical plane in accordance with the reality on the field, the graphic surface differences between the existing assembly on the base plan and the reality on the field have registered under "compensations between parcels" (Forest Management Plan Lugo Forest Management, 2021).

3. The situation of the milestones.

In the state-owned forest fund there are a number of 320 milestones, numbered as follows: 1-13, 25-80, 83, 84, 88-111, 113-224, 226-234, 236, 237, 241-250, 252-255, 257-263, 265-277, 282, 284-289, 302-306, 308-310, 312, 314, 316-



Figure 9. The location plan of the milestones part 1

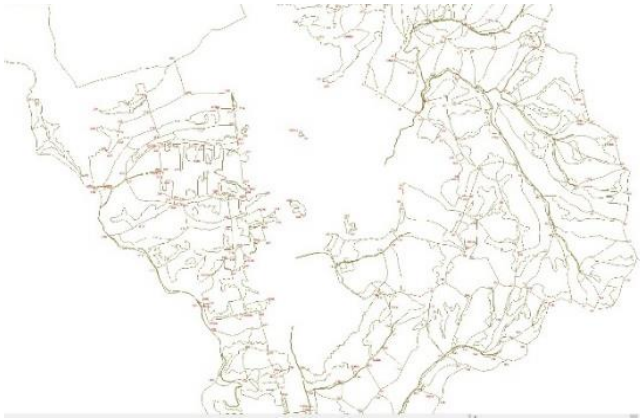


Figure 10. The location plan of the milestones part 2

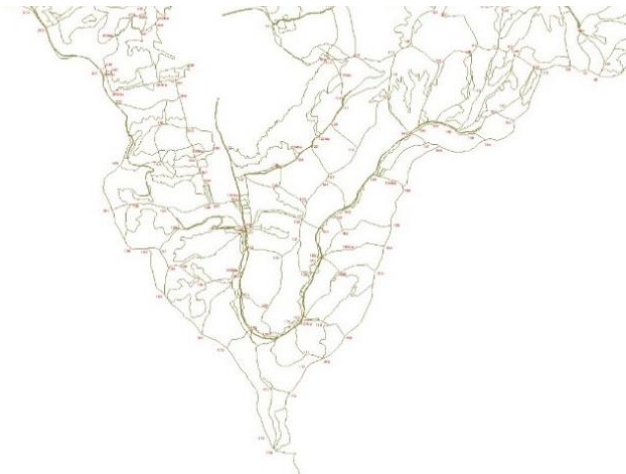


Figure 11. The location plan of the milestones part 3

The milestones are made of reinforced concrete, they have the number written in red paint on a white background, being also materialized on the nearest tree.



Figure 12. Concrete milestone

In order to determine the areas and create the production unit maps, restored aerophotogrametric plans (loose-leaf) with level curves at a scale of 1:5000 were used for the entire area of 12185.39 ha, corrected with recent orthophotoplans and measurements executed with GPS technology.

For the reambulation of the base plans, in situations where the parcel/under-parcel has modified, or where differences were found between the situations on the field and those on the landscaping maps were measured with a GPS device, in total length of 811.41 km, with 22562 points (Forest Management Plan Lugoș Forest Management, 2021).

Table 2. The situation of GPS measurements

The production unit		GPS measurements	
Number	Name	Km	Points
I	Tapia	57,76	1470
II	Valea Lunga	68,11	1386
III	Drinova	212,28	6108
IV	Honorici	21,38	643
V	Sacoșu Mare	18,46	646
VI	Leucușești	433,42	12309
Total O.S.		811,41	22562

The newly created under-parcel for the current arrangement, as well as a part of the forest tree line, were measured with the G.P.S., executing 212.28 km with 6108 points.

The measurements made with the G.P.S. were processed using techniques in AutoCad and were transposed on the base

plans. The base plans equipped in this way constituted the cartographic material on which the areas were determined and the landscaping maps were created to scale 1:20,000, which accompany this arrangement.

5. The area of the forest fund.

The area of the forest fund created following the measurements is 3156.85 ha, which is 40.15 ha less than the previous arrangement of 3197.00 ha. The difference between the two values is justified in the table.

Table 3. The area of the forest fund

The area in the current arrangement	The area in the previous arrangement	Differences		Justifications			
		+	-	Purchase of forest land	Update limit OS Ana Lugojana	Update limit OS Făget	Area retroceded according to the Law 1/2000
3156,85	3197,00	-	40,15	7,76	2,99	3,74	20,06

6. The inventory of the existing and necessary infrastructure for transport.

The existing roads largely satisfy the accessibility and transport needs of the production unit III Drinova. It was considered necessary to build two new forest roads, even if at the current level 92% accessibility is ensured. The main reasons regarding the proposal of the two necessary forest roads and their subsequent construction is the accessibility of some currently inaccessible trees, but also for the easier movement of staff in the field by car (through the connection of the two existing forest roads: Crucea cu Peri, respectively Dracoane).



Figure 13. Forest road

7. Forest constructions

Within the production unit III Drinova there are 4 buildings for the accommodation of forestry staff and workers. No forestry constructions were proposed, the existing ones being sufficient for the accommodation of forestry staff and workers. (Forest Management Plan Lugoj Forest Management, 2021)



Figure 14. Forest Canton of Drinova



Figure 15. Forest Canton of Drinova

CONCLUSIONS

Determining the non-correspondence of the parcel limits materialized in the field with the existing limit on the arrangement plan created by topographical measurements carried out on the parcel limits.

Through the current arrangement, the functional continuity of the forests within the O.S. Lugoj in full accordance with the new socio-economic objectives existing within the range of the forest detour.

Difficulty of measurements in open areas such as meadow.

Making measurements can be difficult due to the signal that is missing in some places but also because of the areas with a very steep slope.

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DIGITAL TOOLS FOR THE CONSTRUCTION SECTOR BIM AND GIS

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Abstract

The paper deals with aspects of the digitization of the construction sector, specifically by detailing the process of adopting the Building Information Modeling (BIM) concept in Romania, in comparison with other European countries. It is based on the data obtained from specialised publications, while also integrating information about the legislative changes proposed for the adoption of BIM. Countries such as Germany, France, or Italy have taken concrete steps regarding the digitization of the construction sector by imposing the use of BIM especially in the projects financed through public funds. In this context, Romania relies on the reforms included in the National Recovery and Resilience Plan and their irreversibility to speed up the digitization of the construction sector.

In order to highlight examples of good practice, references were made to the integration of Geographic Information System (GIS) in cartography and in areas of public administration in Romania, as a component of digitization. Finally, the paper proposes a theme for a transport infrastructure project that will exclusively use digital techniques for the foundation, design, construction and monitoring of the stages related to the investment objective by combining the two tools: BIM and GIS.

Key words: Building Information Modelling, constructions, digitization, Geographic Information System, transport infrastructure

INTRODUCTION

In the European Union, the construction industry is an important economic sector, the turnover generated by it represents 9% of the Gross Domestic Product, contributing with more than 18 million jobs to the common labour market. Unlike other sectors, construction uses 50% of materials extracted from the ground and is responsible for 40% of greenhouse gas emissions.

One of the main disadvantages identified by the industry is the lack of efficiency manifested by unpredictable costs and delays in the delivery and in the operational process of investment objectives.

According to the European Commission, the construction sector is susceptible to be particularly hard hit by financial and economic crises. The main challenges facing construction sector refer to:

Stimulating demand: Efficiency improvements in existing buildings and renovations have the highest potential to stimulate demand.

Training: Improving specialised training and making the sector more attractive, in particular for blue-collar workers, technical colleges and universities.

Innovation: More active uptake of new technologies.

An indicator often used for measuring the performance of this sector is *the gross value added*. Data provided by Eurostat show a fluctuation of 1 percent between 2010 and 2021 in the European Union. Regarding the evolution of this sector in Romania, it can be seen in the attached graph that it has experienced much greater fluctuations compared to what happened in the EU.



Figure 1. GVA evolution of the construction sector_EU and RO

MATERIALS AND METHODS

Regarding the subject of improving efficiency and greening the sector, Building Information Modeling, or simply BIM, has emerged, a collaborative working method that integrates information from all teams connected to a project in order to obtain a single digital representation of the physical and functional characteristics of a construction objective .

BIM uses design tools and technologies that involve the creation, generation and management of information in a queryable database. It is a process that covers the entire life cycle of a construction project starting with plans, drawings (2D) in CAD (Computer Aided Design) and then going through digital 2D and 3D CAD. BIM is thus more than 3D modelling. Seen as a defined concept, BIM is structured on two levels, **dimension** and **stage**.

Dimension refers to the integration of different types of data and information, as follows:

- 3D BIM includes the digital model of the entire project
- 4D BIM includes the 3D model to which the temporal dimension is added, by integrating the execution times related to each stage
- 5D BIM includes the 3D model plus associated costs
- 6D BIM includes the 3D model to which the "facility management" component is added for an efficient management of the benefits obtained through the implementation of the project
- 7D BIM includes the 3D model and integrates sustainability elements of the construction

On the other hand, **stage** defines the level of collaboration and the flow of information between the teams involved in the development of the project.

- S0 contains 2D CAD modelling on paper, where collaboration is lacking
- S1 includes 2D and 3D CAD modelling, partial collaboration by introducing spatial coordination
- S2 includes 3D modelling along with time and cost dimensions, the data being interoperable and shared
- S3 stands for integrated BIM throughout the entire life cycle of a project

RESULTS AND DISCUSSIONS

COUNTRY	Date on which BIM became mandatory	Construction companies that use BIM (%)
UK	2016 for public funded investments	73%
Germany	2017 for projects that surpass 100 mil. EUR	70%
Poland	2030 for large construction projects financed through public funds	43%
France	January 1st, 2022	35% – real estate 50-60% of the construction companies

Croatia	not mandatory	25% of the designers 4% of the beneficiaries
Austria	2018-20 for controlling the operational costs of public buildings	20%
Russian Federation	March 1st, 2022 for all projects financed through public funds	12%

Figure 2. BIM adoption in various countries

We also refer to the study „*Integration and impact of BIM in the rehabilitation of buildings in developing countries*”, whose scope is to compare the conventional and the BIM-based approaches in projects regarding the building rehabilitation. The study focused on a block of buildings containing a medico-social centre in Douala and on two other ancillary sites in Cameroon, an emerging economy, thus being in a proper position when it comes to adopting new technologies.

The methods applied for the BIM-based approach of building rehabilitation include collaborative management of the project, modelling of the building, cost estimation, development of project programme and maintenance of the building.

As seen in the diagrams below, the results revealed a gain of approximately 22% on the cost, and of approximately 14 days on the duration of the work between the classic method and the optimised BIM method.

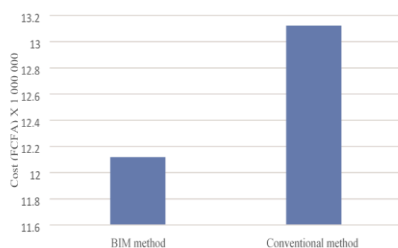


Figure 3. Comparison project cost for BIM vs. Conventional methods

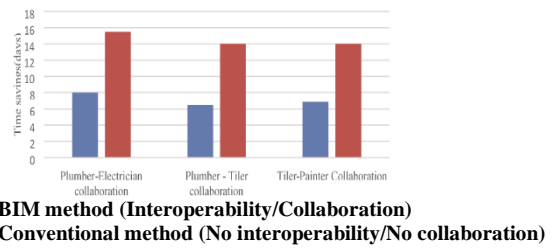


Figure 4. Time saving due to interoperability/collaboration between professionals

GIS IN ROMANIA

The GIS (Geographic Information System) is the system that allows the collection, management and analysis of data. The data that GIS manages can be of vector and raster type. Through data processing, graphic products can be obtained that facilitate the transmission of information in several fields, such as: environmental analysis, urban development and planning, telecommunications, transport and many others.

In Romania, Geographic Information Systems (GIS) have become increasingly popular among public institutions that have integrated them into their analyses. For example, GIS can be used in the spatialization and analysis of transportation systems. In the example in figure 5, GIS was used to represent a concept of a bridge-type structure designed for the railway link in the Port of Constanța .



Figure 5. Representation of the railway line from the port of Constanța using GIS

BIM IN ROMANIA

In Romania, on the national level, the strategy for digitalization of the construction sector targets the adoption of new technologies. Regarding BIM, in September 2022, a Memorandum was signed between institutional stakeholders with the subject of **”Approval of the Roadmap regarding the implementation of the BIM methodology at the national level, in investment projects financed from public funds in the construction sector”**.

The BIM maturity stage considered as the starting level for the BIM implementation process in Romania must be at least the BIM2 maturity stage (BIM Level 2) and its adoption is part of the National Recovery and Resilience Plan, the main mechanism for accelerated reforms in all economic and administrative sectors.

According to the Memorandum, the implementation of pilot projects using BIM should start in the second half of 2024 and by 2029, BIM development and expansion will be integrated on a large scale.

In the same way, with the help of the line designed in GIS, they were transposed in Infracworks, a software that has integrated the BIM model, to realistically represent the future bridge (Figure 5).

With the help of Infracworks, the technical characteristics of the bridge were set, such as the opening of the piles, the materials used or the height in relation to the ground level



Figure 6. Representation of the railway line from the port of Constanta using Infracworks (BIM)

CONCLUSIONS

To conclude, the development of the BIM concept and its implementation represent an important step in the construction sector in Romania. The biggest advantage of BIM is that it is a digital tool that can track the progress of a project from the proposal stage to its completion. The disadvantages are given by the high costs for the purchase of the software and for the training of specialists in the field.

BIM as well as GIS are tools that require interdisciplinarity in use to maximize results. Their applicability represents an important step in the evolution of the construction system and not only in Romania, and they are the key to the development of technology and specialists.

The transport infrastructure could be one of the main beneficiaries of the BIM and GIS integration by providing an integrated approach on the various projects' entire life cycle. For example, we propose the integrated approach for the modernization of the Sinaia railway station, a project financed through European funds in the recently adopted Transport Program 2021 - 2027.

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DYNAMICS OF THE PROTECTED AREA SEMENIC-CHEILE CARAȘULUI NATIONAL PARK IN THE PERIOD 2015-2022 USING GIS TECHNOLOGY AND LANDSAT REMOTE SENSING IMAGES

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Abstract

This study aimed to analyze and characterize a protected area based on satellite imagery. Protected areas are terrestrial or aquatic areas specially designed to protect and maintain biodiversity, natural resources and related cultural resources. Remote sensing is the technology by which objects can be measured, identified and analyzed from a distance, without the need for direct contact. Thus, for the analysis of satellite images, we used the data obtained from Landsat 8. Semenic-Cheile Carasului National Park was studied under the aspect of the variation of NDVI, NDMI and NBR indices. It was considered a period of seven years, 2015-2022, for the study, and as the period of the year the summer season was taken into account. Satellite scenes, Landsat 8, were used, taken in August during the study period. Based on spectral information and established formulas, NDVI, NDMI and NBR indices were calculated. To better analyze the features in pictures, we use band combinations. We accomplish this by creatively rearranging the available channels. We can extract specific information from an image by employing band combinations. It can be seen how Semenic-Cheile Carasului changed its dynamics over the years.

Key words: indices, Landsat 8, NDVI, protected area, satellite imagery.

INTRODUCTION

Remote sensing is the acquisition of information about an object or phenomenon without physically coming into contact with the object, as opposed to in situ or on-site observation (Herbei and Sala, 2016). The term is especially applied to obtaining information about Earth and other planets. Remote sensing is used in many fields, including geography, topography, and most Earth science disciplines (e.g., hydrology, ecology, meteorology, oceanography, glaciology, geology); it also has military, intelligence, commercial, economic, planning and humanitarian applications, among others (Schowengerdt, 2007).

Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft). Special cameras collect remotely sensed images, which help researchers "sense" things about the Earth (<https://www.usgs.gov>). The Semenic-Cheile Carasului National Park is a protected area of national interest that

corresponds to IUCN category II (national park, special conservation area), located in the south-western part of Romania, on the territory of Caraș-Severin county (Grigore, 1990).

The Semenic Mountains and the Anine Mountains (comprising natural elements of value from a physical-geographical, floristic, hydrological, geological and speleological aspect) present a natural mountain area with a diverse range of flora and fauna, expressed both at the level of species and at the level of ecosystems terrestrial (Abran, 2012). The protected area is located in the central-western part of Caraș-Severin county (on the administrative territories of the cities of Anina and Reșita and those of the communes of Bozovici, Brebu Nou, Carașova, Goruia, Mehadica, Prigor, Teregoava and Văliug) (www.protectedplanet.net).

Study of land areas based on satellite images (remote sensing techniques) and analysis imaging, is important as a result of the variable coverage area, in relation to the area of interest and the resolution of the images, the high level of details, the indexes that can be calculated for

to evaluate, analyze and characterize a certain situation. The objectives of the work were to provide a package of useful data, through some indices and representative parameters in the characterization and management of land areas. The studied area was chosen because it presents a very high diversity, in relation to the different elements taken into consideration (natural or artificial), so that in relation to the proposed objectives it requires to appropriate methods and indices are used (Herbei, 2015).

The surface of the park is 36664.80 ha, its maximum altitude is 1400m, the minimum altitude is 230m, and the average altitude is 815m (Herbei and Sala, 2014).

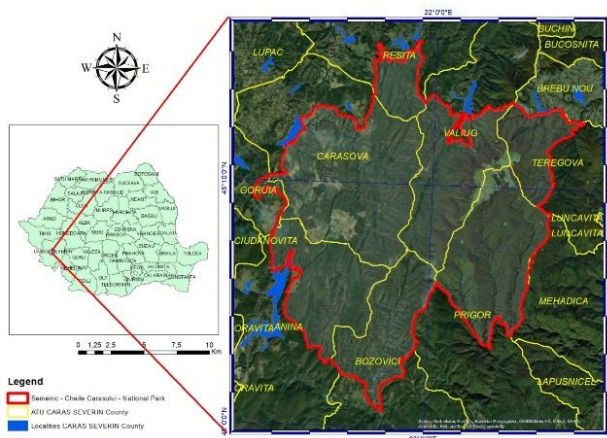


Figure 1. Location of the studied area

MATERIAL AND METHOD

The Landsat Data Continuity Mission has a successful launch February 11th 2013. It was officially renamed to Landsat 8 on May 30, 2013. The newest satellite in the Landsat series offers scientists a clearer view with better spatial resolution than most ocean-sensing instruments and greater sensitivity to brightness and color than previous Landsats.

Landsat 8 (formerly called the Landsat Data Continuity Mission, or LDCM) is NASA's eighth satellite in the Landsat series and continues the Landsat program's critical role in monitoring, understanding and managing the resources needed for human sustainment such as food, water and forests. As our population surpasses seven billion people, the impact of human society on the planet will increase, and Landsat monitors those impacts as well as environmental changes. Research of land area from airspace and outer space using remote

sensing techniques delivers valuable information for many industries, among which: agriculture, forestry, geology, soil, hydrology, cartography, exploration and evaluation natural resources, environmental monitoring (soil, water and air) and others. Landsat images can be used successfully in a number of scientific applications and practical problems: global urbanization, wetland delineation, detecting changes.

The Landsat program offers the longest continuous global record of the Earth's surface; it continues to deliver visually stunning and scientifically valuable images of our planet. Since the early 1970s, Landsat has continuously and consistently archived images of Earth; this unparalleled data archive gives scientists the ability to assess changes in Earth's landscape.

For over 40 years, the Landsat program has collected spectral information from Earth's surface, creating a historical archive unmatched in quality, detail, coverage, and length.

This is an important spatial resolution because it is coarse enough for global coverage, yet detailed enough to characterize human-scale processes such as urban growth.

Operational Land Imager (OLI) contains nine spectral bands, including a pan band: band 1 Visible (0.43 - 0.45 μm) 30 m; band 2 Visible (0.450 - 0.51 μm) 30 m; band 3 Visible (0.53 - 0.59 μm) 30 m; band 4 Red (0.64 - 0.67 μm) 30 m; band 5 Near-Infrared (0.85 - 0.88 μm) 30 m; band 6 SWIR 1(1.57 - 1.65 μm) 30 m; band 7 SWIR 2 (2.11 - 2.29 μm) 30 m; band 8 Panchromatic (PAN) (0.50 - 0.68 μm) 15 m; band 9 Cirrus (1.36 - 1.38 μm) 30 m (<https://landsat.gsfc.nasa.gov/satellites/landsat-8/>).

To characterize the area under study, satellite images taken on summer season, in the Landsat 8 system, were used.

Table 1. Acquisition of satellite images

Satellite images	Acquisition date
Landsat 8	15.08.2015
Landsat 8	04.08.2017
Landsat 8	28.08.2020
Landsat 9	26.08.2022

NBR indices, equation (1), NDVI index, equation (2), and NDMI index, equation (3) were calculated.

$$NBR = (NIR - SWIR) / (NIR + SWIR) \quad (1)$$

(Kriegler et al., 1969)

$$NDVI = (NIR - RED) / (NIR + RED) \quad (2)$$

(Rouse et al., 1974)

$$NDMI = (NIR - SWIR) / (NIR + SWIR) \quad (3)$$

(Gates and David, 1980)

The NBR index (The Normalized Burn Ratio) is used to identify burned areas in fire areas. The formula is similar to that of NDVI; however, it uses both near-infrared (NIR) and short-wave infrared (SWIR) wavelengths. Thus, healthy vegetation has high NIR reflectance and low SWIR reflectance, which is the opposite of what is seen in fire-ravaged areas. A high NBR value suggests healthy vegetation, while a low value indicates barren land and regions that have been recently burned. Values close to 0 are usually attributes of unburnt areas (Herbei, 2015).

NDMI (The Normalized Difference Moisture Index) uses a combination of near infrared (NIR) and short wave infrared (SWIR) spectral bands to detect plant moisture levels. It is a solid indicator of water stress in agriculture. NDMI can only have values between -1 and +1. Negative numbers approaching -1 indicate water stress, while positive values suggest water binding (Richards, 1999).

NDVI (Normalized Difference Vegetation Index) measures the difference between near infrared and red light to quantify vegetation. The most used index in remote sensing is NDVI (Herbei et al., 2015).

Table 2. Description of NDVI intervals for vegetation cover

CLASS	CLASSIFICATION CRITERIA
Bare soil/water	$NDVI \leq 0$
Very low	$0 < NDVI \leq 0.2$
Low	$0.2 < NDVI \leq 0.4$
Moderately low	$0.4 < NDVI \leq 0.6$
Moderately high	$0.6 < NDVI \leq 0.8$
High	$0.8 < NDVI \leq 1$

RESULTS AND DISCUSSIONS

The analysis of the dynamics of the Semenic-Cheile Carasului national park was done by calculating the NDVI, NDMI and NBR indices, as well as by comparing the combinations of spectral bands.

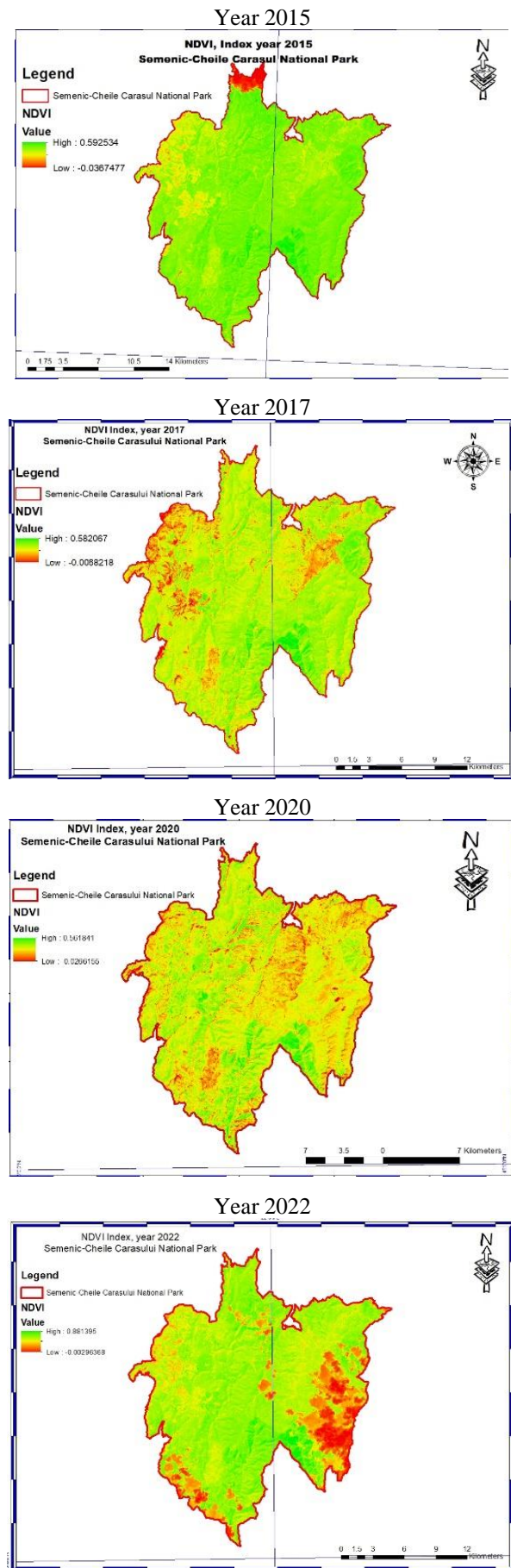


Figure 2. NDVI index

By calculating the NDVI index, it can be seen that the vegetation in 2015 is much healthier than the following years.

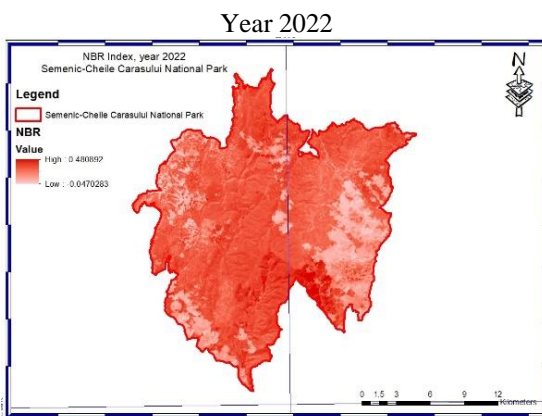
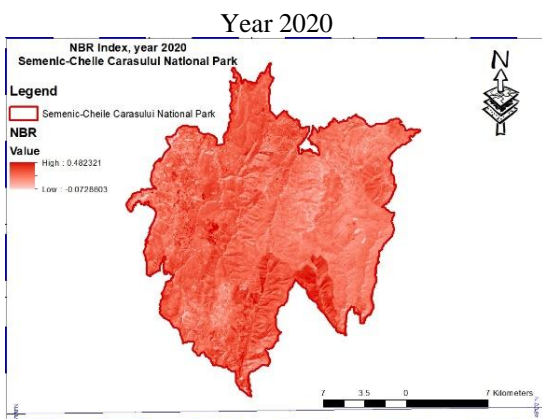
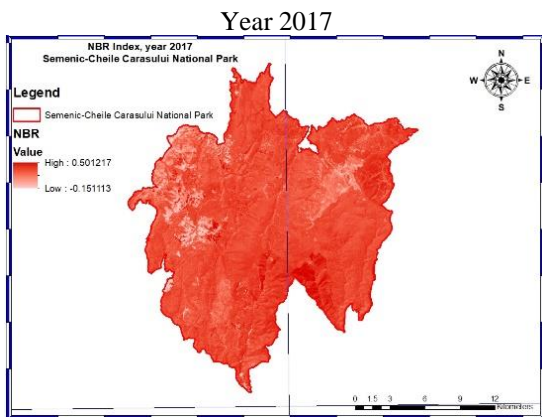
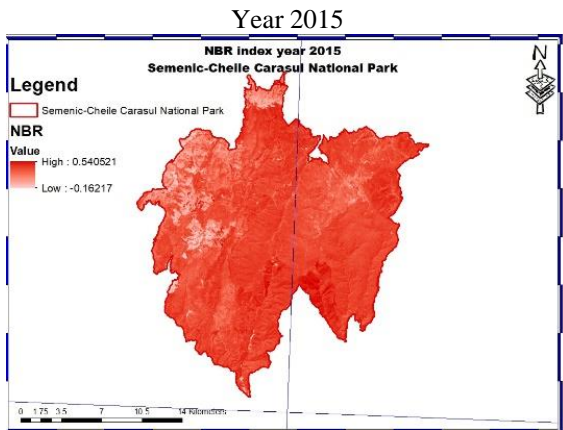


Figure 3. NBR index

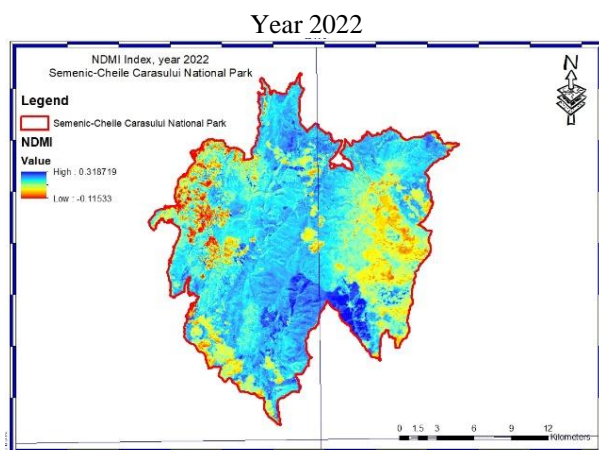
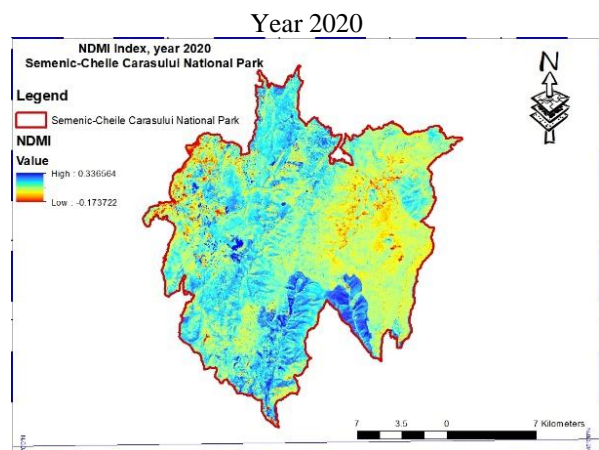
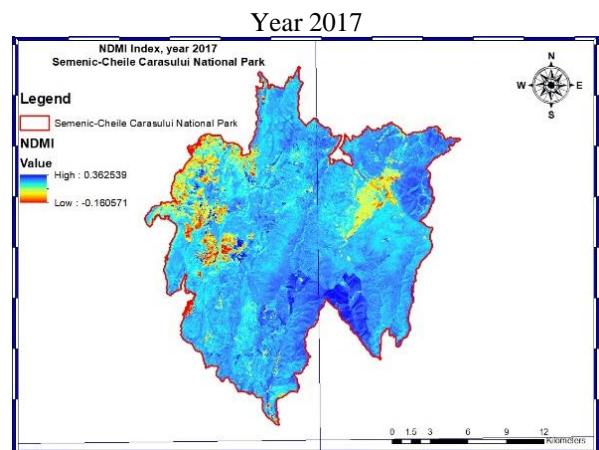
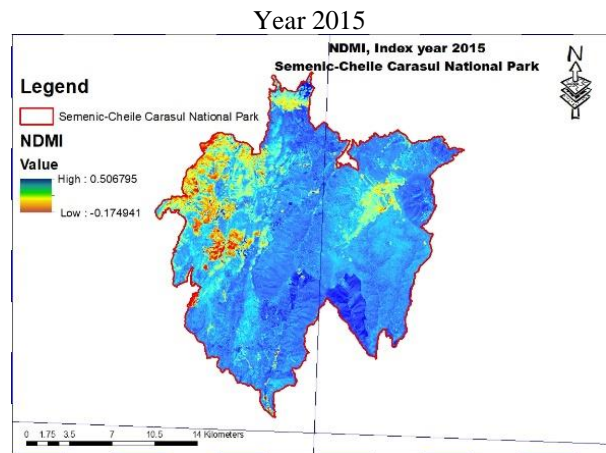


Figure 4. NDMI index

Considering the rainfall recorded in 2022 (76-125mm), it can be seen that there is no water stress on the studied area.

Red (4), green (3), and blue (2) make up the band combination used in the natural color composite. It closely resembles what our eyes can see. Green denotes healthy vegetation, whereas brown denotes unhealthy flora. Water is either dark blue or black, and urban characteristics are white and grey. Natural Color is used to represent an image in natural colour and therefore best approaches the appearance of the landscape in reality. Band 3 detects chlorophyll absorption in vegetation (thus low reflection). Band 2 detects the green reflectance from vegetation. Band 1 is more suited for penetration in water, in clear water this can be some 25 meters. On the other hand one can also derive information about sediment transportation in water from this band. Band 1 also differentiates between soil and vegetation and distinguishes forest types. These bands, which have a vivid green appearance, are helpful for monitoring agricultural crops. Uncultivated vegetation appears as more muted tones of green and bare dirt appears as a magenta colour.

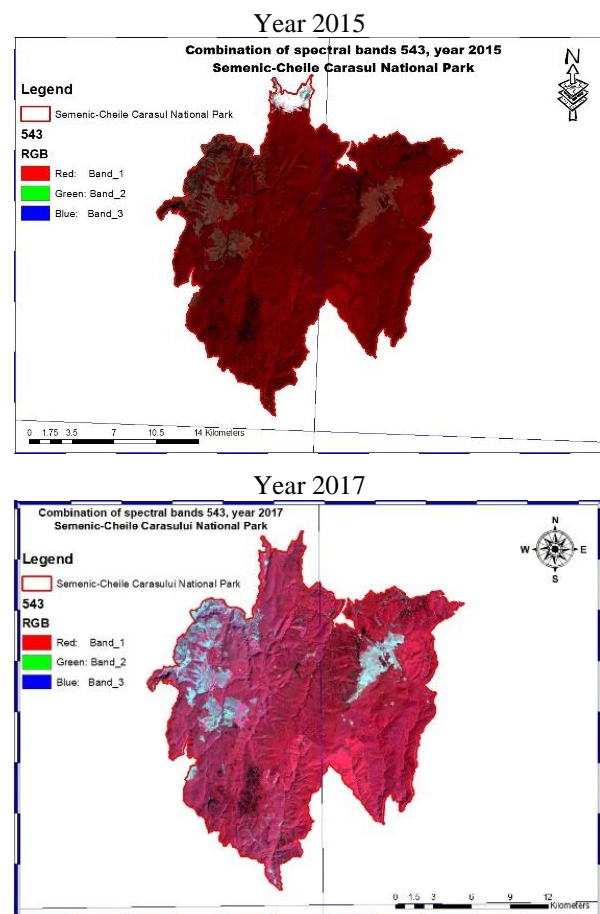
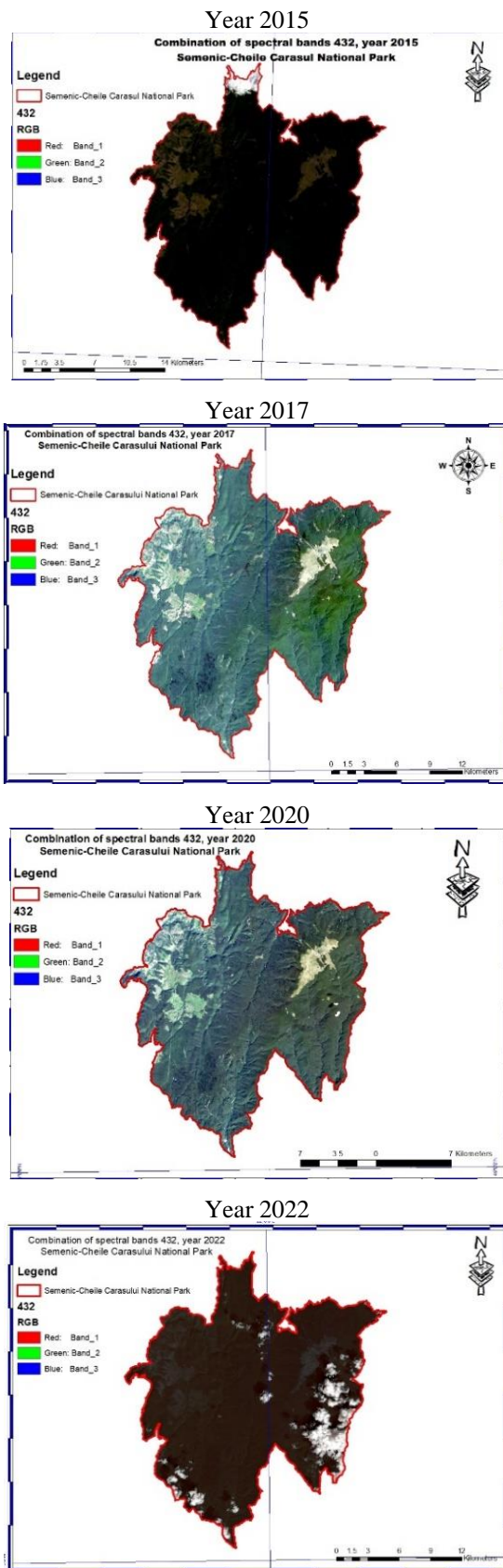


Figure 5. Combination of spectral bands 432

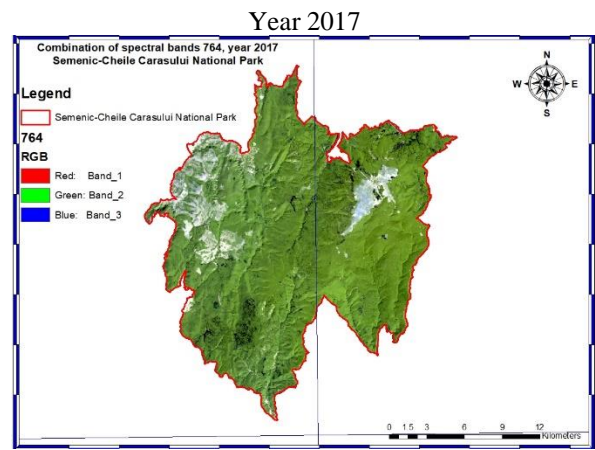
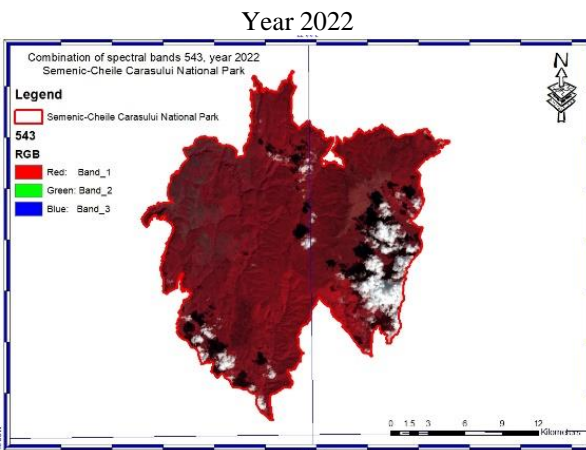
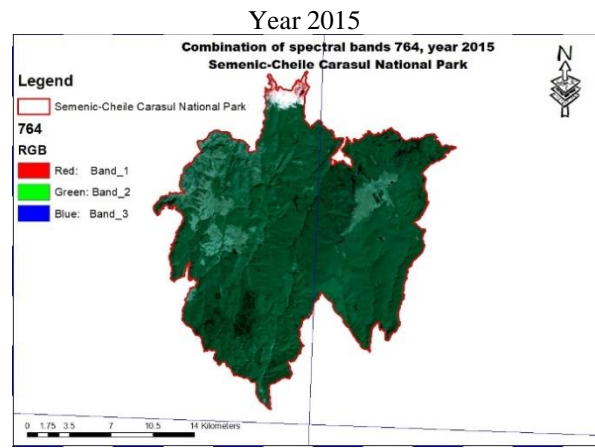
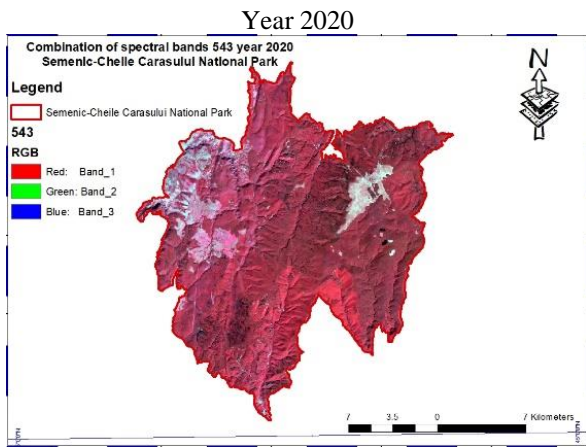


Figure 6. Combination of spectral bands 543

The term "near-infrared (NIR) composite" is also used to refer to this band combination. It employs red (4), green (5), and near-infrared (3). While near-infrared light is reflected by chlorophyll, this band composition is helpful for examining plants. Particularly, the reddish regions have healthier vegetation. Water is in the dark, and cities are white.

Bands 5, 4, and 3 are falsely colored crimson, green, and blue, respectively, while band 5 is blue. Coniferous forests are depicted in darker red or even brown than deciduous forests, whereas plantations are indicated by the color red. Urban areas are indicated by the color green-blue, while water bodies are near to the color black.

The outcomes of this band combination are comparable to those of conventional color infrared aerial photography. This band combination is helpful for crop growth stages, drainage and soil pattern monitoring, and vegetation studies.

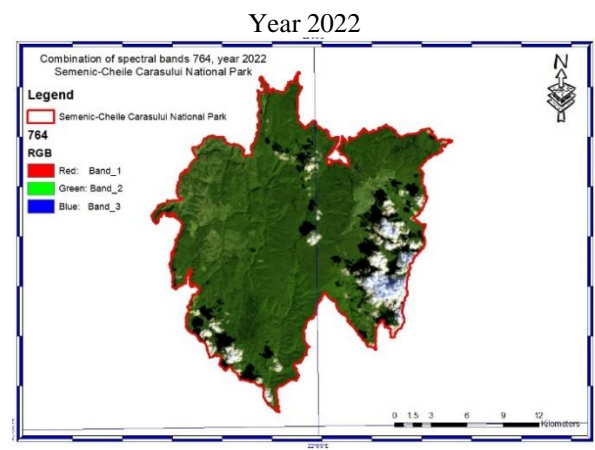
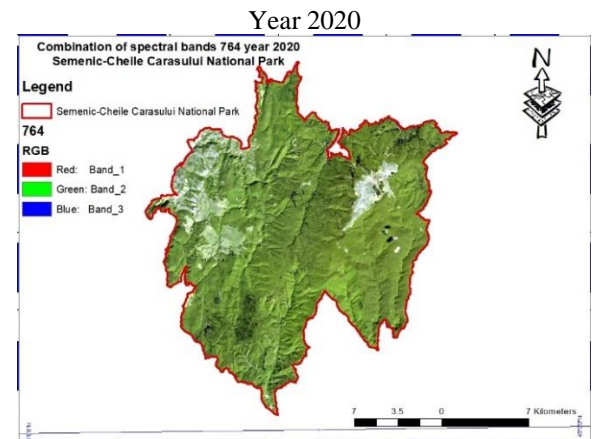


Figure 7. Combination of spectral bands 764

Red, SWIR-1, and SWIR-2 are the components of the short-wave infrared band combination (4). Green hues can be seen throughout the plants in this composite. Denser vegetation is represented by darker shades of green, whilst sparse vegetation is represented by lighter hues. While soils have varying tones of brown, urban areas are blue.

For this band, vegetation appears in shades of dark and light during the growing season, and urban features are white, grey, cyan or purple. Snow and ice appear as dark blue.

This band combination on Landsat 8 uses both of the SWIR bands, which results in a sharper image than band combinations that use shorter wavelength bands, which are more prone to haze.

CONCLUSIONS

Remote sensing data is very valuable in mountain environments due to the ability to extrapolate the information gathered from detailed surveys into accessible areas in large regions inaccessible, thus allowing us to fill the substantial knowledge gaps we have about the pattern and rate of vegetation change in such areas. regions. Classification of images by remote sensing commonly uses data from pixel values where the ecological situation on terrain is well known to establish a rule or a set of rules to extrapolate pixels which appear spectrally similar.

The method provides useful information for the general management of the area, works specific, warnings, or the development of objectives of interest, such as the ski area.

The information obtained can be corroborated with data and weather information to make some methods and models of information and forecasting for the studied area, regarding certain moments risk (floods, avalanches, etc.), monitoring, or development.

Remote sensing monitoring can provide essential information for the efficient, transparent, repeatable and defensible decision making in ecological systems. Remote sensing has unique advantages in monitoring the landscape dynamics in the world.

To investigate the studied area in more detail, several combinations of spectral bands can be analyzed, as well as an analysis of land cover classes (Corine Land Cover).

Thus, GIS has an important role in improving the digital processing of images in areas mountains.

ACKNOWLEDGMENTS

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SECTION 05
FUNDAMENTAL SCIENCES

CARL FRIEDRICH GAUSS – PRINCEPS MATHEMATICORUM

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Figure 1. Carl Friedrich Gauss (1777-1855)

Abstract

Johann Friedrich Carl Gauss, was a German mathematician and physicist who made important contributions to many fields of mathematics and many different domains in science. Sometimes referred to as the Princeps mathematicorum (Latin for “the foremost of mathematicians”) and “the greatest mathematician since antiquity”, Gauss is considered among the most influential mathematicians throughout history.

Keywords: Carl Friedrich Gauss, geodesy, mathematics, mathematical work, science.

INTRODUCTION

Carl Friedrich Gauss, original name Johann Friedrich Carl Gauss, was a German mathematician and a child prodigy. He was able to calculate before he could even talk and his

contributions to number theory, the theory of functions, probability theory, geodesy, geometry, planetary astronomy and potential theory made him one of history’s greatest and most influential mathematicians.

EARLY YEARS

Carl Friedrich Gauss was born on April 30, 1777, in Brunswick, Germany. His parents were Gebhard Dietrich Gauss, a gardener and bricklayer, and Dorothea Benze, the daughter of a well-to-do family. From an early age, Gauss showed exceptional mathematical abilities, and he quickly became fascinated with numbers and problem-solving. His mother was illiterate and never recorded the date of his birth, the only clue about his birthday was that he born on a Wednesday, 39 days after Easter. Later, Gauss discovered the mystery of his birthdate with methods to compute the date of Easter in both past and future years.

As a child, Gauss was mostly self-taught, as his parents were not educated enough to provide him with formal instruction. Nevertheless, he made remarkable progress in mathematics and other subjects, and he began to attract the attention of local scholars and patrons.

ELEMENTARY SCHOOL

At the age of 7, in the year 1784, he began attending a public elementary school. An often-told story, with varying details, is that his primary school teacher, J.G. Büttner, attempted to occupy his students by having them add up the integers from 1 to 100. However, to the surprise of all, the young Gauss arrived at the correct answer almost instantaneously, thanks to a sudden mathematical insight. Gauss had realized that adding up pairs of terms from opposite ends of the list would result in identical intermediate sums.

$$1 + 2 + \dots + n = \frac{n(n+1)}{2} \quad (1)$$

At the age of ten, he became friends with a teacher's assistant who helped him obtain mathematics books that they studied together.

HIGH SCHOOL AND UNIVERSITY

After completing elementary school, he was admitted to a gymnasium (high school) in 1788. Within just two years, he had excelled to such a remarkable degree that he was presented to the Duke. As a reward for his academic skills, Gauss was given a fellowship to attend the Collegium Carolinum, which is now known as the Technische Universität Braunschweig. He studied there from 1792 to 1795 before moving

on to the University of Göttingen, where he continued his studies from 1795 to 1798.

At the age of 19, Gauss achieved a significant breakthrough in mathematics by demonstrating that a straightedge and a compass could construct any polygon with a number of sides equal to a Fermat prime. This proof marked the first advancement in polygon construction in over two millennia. The construction of a regular heptadecagon, a 17-sided polygon, using this method while he was still a student, was a groundbreaking discovery that inspired Gauss to pursue a career in mathematics.

In 1796, Gauss accomplished another remarkable step by becoming the first mathematician in the world to prove the law of quadratic reciprocity in number theory, which he named the "fundamental/golden theorem." That same year, he also formulated the prime number theorem, although he did not publish it. Gauss usually refused to present the intuition behind his often highly sophisticated evidence - that they appeared "suddenly" and erased any trace of how he discovered them, which is justified, although overwhelming in the work "Disquisitiones Arithmeticae", published when Gauss was 24 years old, in 1801. This seminal work served as the basis for the systematic study of number theory as a distinct field of inquiry. During his studies at the University of Göttingen, Gauss made a notable discovery, which he detailed in Section VII of his book. Additionally, he introduced the symbol for congruence in geometry.

DISSERTATION

In 1799, as part of his doctoral dissertation, Gauss presented a proof of the fundamental theorem of algebra, which asserts that every polynomial equation with complex coefficients has at least one complex root. This work represented an important contribution to the field of mathematics. Additionally, Gauss made significant strides in determining the number of solutions for polynomial equations with coefficients in finite fields. His findings formed the foundation for the Weil conjectures in 1949.

In the field of differential geometry, Carl Gauss introduced the concept of "Gaussian curvature" as a measure of intrinsic curvature. This concept

led to the development of Gauss's Theorema Egregium, a fundamental result in differential geometry. Gauss's work in this area remains influential to this day.

APPRAISAL OF GAUSS

The British mathematician Henry John Stephen Smith (1826–1883) gave the following appraisal of Gauss: “If we except the great name of Newton it is probable that no mathematicians of any age or country have ever surpassed Gauss in the combination of an abundant fertility of invention with an absolute rigorousness in demonstration, which the ancient Greeks themselves might have envied. It may seem paradoxical, but it is probably true that it is precisely the efforts after logical perfection of form which has rendered the writings of Gauss open to the charge of obscurity and unnecessary difficulty. Gauss says more than once that, for brevity, he gives only the synthesis, and suppresses the analysis of his propositions.” (Smith H.J.S.)

RELIGIOUS VIEWS

Gauss was a Protestant Lutheran, a member of St. John the Evangelist Lutheran Church. Alani of Göttingen. One of his biographers, G. Waldo Dunnington, described Gauss' religious conceptions in these terms: “For him, science was the means of discovering the immortal core of the human soul. It entertained him on days when he was plentiful and, through the views he opened, offered him comfort. At the end of his life, that gave him confidence. The Gaussian God is not a cold and distant invention of metaphysics or a twisted caricature of bittersweet theology. No one can guarantee the completeness of knowledge enough to justify his arrogant assertion that clairvoyance is all light, and no one else can report the truth like him. For Gauss, it was not the man who whispered his creed, but the man who put it into practice. He believed that being worthy on earth was the best and only preparation for heaven. Religion is not a matter of literature, it is a matter of life. Divine

revelation is continuous and is not contained in sacred tablets or scrolls.” (Dunnington, 1955).

PERSONALITY

Karl Gauss was a passionate perfectionist and a hard worker. He was never a prolific writer and refused to publish works that he considered incomplete and uncritical. This matched his personal motto “*pauca sed matura*” (“small but ripe”). His personal diaries show that he made some important mathematical discoveries years and decades before they were published by his contemporaries. Math historian Eric Temple Bell said that if Gauss had published all his findings in time, he would have made 50 years of progress in mathematics. (Bell E.T., 2009) Despite his introverted personality trait, Gauss was highly respected by his colleagues and contemporaries for his contributions to the fields of mathematics, physics, and astronomy. He was known for his meticulous attention to detail and his ability to solve complex problems with great accuracy and speed.

Gauss was also a deeply patriotic individual who was proud of his German heritage and identity. He was known for his support of the German language and culture, and played a role in the development of a standard system of measurement for the German states.

In addition to his intellectual pursuits, Gauss was also interested in music. He played the piano and organ. He was married twice and had six children, two of whom also became mathematicians.

LATER YEARS AND DEATH

In 1831, Gauss collaborated successfully with the physicist Professor Wilhelm Weber, introducing new knowledge of magnetism and discovering Kirchhoff's laws of electrical circuits. During this time, he developed the law of the same name. They built the first electromechanical telegraph in 1833, linking the observatory to the Institute of Physics in Göttingen. Gauss ordered the construction of a magnetic observatory in the Observatory Garden and together with Weber founded the “Magnetischer Verein”, which allows the

measurement of the Earth's magnetic field in many regions of the world.

Gauss died on 23 February 1855 in Göttingen (then the Kingdom of Hanover and now Lower Saxony) ("Carl Friedrich Gauss". Wichita State University.) and he was buried there in Albany Cemetery. Two people commended his funeral: Gauss's son-in-law Heinrich Ewald and Gauss's close friend and biographer, Wolfgang Sedorius von Waltershausen (Wolfgang Sartorius von Waltershausen). Rudolf Wagner retained and studied his brain and found that it weighed 1,492 grams (slightly above average) and had a brain area of 219,588 mm². (This reference from 1891 (Donaldson H., 1891) says: "Gauss, 1492 grm. 957 grm. 219588. sq. mm."; i.e. the unit is mm². In the later reference: Dunnington (1927), the unit is erroneously reported as square cm, which gives an unreasonably large area; the 1891 reference is more reliable.) (340,362 square inches).

He also discovered highly developed circumvolutions, which were believed to explain his genius at the beginning of the twentieth century (Bardi, 2008). Throughout his lifetime, his discoveries were recorded in his personal journal, but he did not publish them. These notable findings include the method for fitting least squares, the Cauchy integral theorem for analytic functions, and non-Euclidean geometry.

AWARDS AND ACHIEVEMENTS

In 1810, he was honored with the Lalande Prize by the French Academy of Sciences for recognizing his contributions to astronomy.

He received the prize of the Danish Academy of Sciences in 1823 for the study of maps that preserve the angle.

He was presented with the Copley Medal by the Royal Society, London, in 1838 "for his inventions and mathematical research in magnetism".

THE GAUSS PRIZE

The Gauss Prize is to honor scientists whose mathematical research has had an impact outside mathematics – either in technology, in business, or simply in people's everyday lives. The prize is awarded jointly by the Deutsche Mathematiker-

Vereinigung (German Mathematical Union) and the International Mathematical Union.

Material - Au 585/00 (14KT Gold)

Diameter - 65 mm

Weight - 155.5 g

Cutting depth - 0,25-0,30 mm, embossed outer edge

Package - Case of mahogany

The 2010 cash value of the Gauss Prize 10,000 EUR.



Figure 2. The Gauss Medal

Interpretation of the medal

Soon after Giuseppe Piazzi discovered the celestial body Ceres on January 1st, 1801, Ceres disappeared from view, and there were no reliable techniques available to predict its orbit from Piazzi's limited observational data. Introducing a revolutionary new idea, the now well-known least squares method, Carl Friedrich Gauss was able to calculate Ceres' orbit in a very precise way, and in December 1801 Ceres was

rediscovered by the astronomer Zack very close to the predicted position.

This impressive example illustrating the power of the applications of mathematics provided the general idea for the design of this medal.

Dissolved into a linear pattern, the Gauss effigy is incomplete. It is the viewer's eye which completes the barcode of lines and transforms it into the portrait of Gauss.

A similar pattern, accomplished by horizontal lines, is one of the features on the back of the medal. This grid is crossed by a curve. The disk and the square, two elements connected by the curve, symbolize both the least squares method and the discovery of Ceres' orbit.

The mathematical language has been reduced to its most fundamental elements, such as point, line and curve. Moreover, these elements represent natural processes. The imagery of the medal is a synthesis of nature's and mathematics' sign language.

Medal designer Jan Arnold.

MATHEMATICAL WORK

Gauss published more than 150 works which had a great impact on different scientific domains. We mention below some of his contributions.

1. Construction of Heptadecagon

Gauss constructed a regular 17-sided polygon, heptadecagon with the help of straightedge and compass only, when he was just 19. His proof says that the number of sides of the regular polygon is distinct Fermat primes, which are of $F_n = 2^{2^n} + 1$, $n \in \mathbb{N}$. Gauss discovered a general formula for construction polygon beyond heptadecagon. He further constructed other n-sided figures. Gauss-Wantzel's theorem (completely proven in 1873) states that a regular n-sided polygon can be constructed with the straightedge and the compass if and only if

$$n = 2^k F_1 F_2 \dots F_m \quad (2)$$

where $F_1 F_2 \dots F_m$ are Fermat primes.

Gauss was so happy with his result that he asked the stoneman to inscribe a heptadecagon over his tomb. However, the stoneman declined by saying that the difficult construction of a

heptadecagon will look like a circle only.

2. Integers as sum of Triangular Numbers

In 1796, Gauss discovered that every positive integer can be expressed as the sum of at most three triangular numbers, i.e. numbers of the form $\Delta = \frac{n(n+1)}{2}$.

He wrote this result in his diary as,

$$\text{“EYPHKA num} = \Delta + \Delta + \Delta\text{“} \quad (3)$$

This diary was lost after 40 years of his death. Gauss was supposed to be the last person who mastered every aspect of mathematics.

3. Complex Numbers

Even though complex numbers are known from the 16th century, Gauss was the first mathematician to give a clear picture of complex numbers and functions of complex variables. Although Euler worked on imaginary and complex numbers, there was still no proper explanation of how real and imaginary numbers are related. Gauss took into practice the complex numbers and gave the standard notation $a+ib$ for complex numbers. Then onwards, more concepts of complex numbers were unleashed.

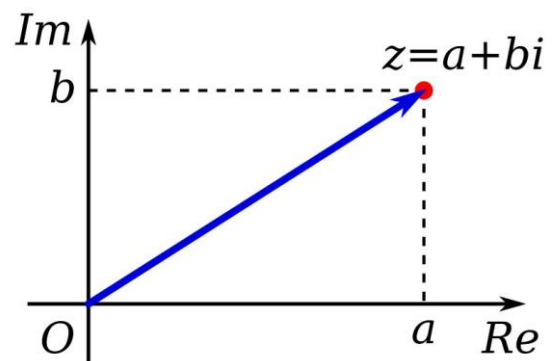


Figure 3. Complex numbers

4. Fundamental Theorem of Algebra

When he was just 22, Gauss gave the proof of the Fundamental Theorem of Algebra, which states that every non-constant single-variable polynomial over the complex numbers has at least one root.

He also proved that the field of complex numbers \mathbb{C} is algebraically closed (a polynomial with complex coefficients has at least one complex root) unlike the field of real numbers \mathbb{R} , where a polynomial with real coefficients may have only complex roots.

5. Contributions to Number Theory

Gauss used to say that “Mathematics is the queen of sciences and number theory is the

queen of mathematics.” In 1801, at the age of 24, Gauss published his most famous book “Disquisitiones Arithmeticae”, written in latin, which is considered the most influential book in the field of number theory. This book includes,

- Triple bar symbol (\equiv) for congruence;
- Presentation of Gauss’ method of modular arithmetic;
- The first two proofs of the law of quadratic reciprocity;
- Theories of binary and ternary quadratic forms;
- Gauss class number problem;
- Proved Fermat’s polygonal number theorem for $n = 5$;
- Descartes’ rule of signs
- Kepler’s conjecture for regular arrangements
- Calculating the date of Easter
- Discovered Cooley-Tukey FFT algorithm for calculating Discrete Fourier transforms (rediscovered and popularized);

6. Properties of Pentagramma Mirificum

Some properties of Pentagramma mirificum were discussed by Gauss. Pentagramma mirificum is a star-shaped polygon on a sphere whose sides are great circle arcs and all the interior angles are right angles.

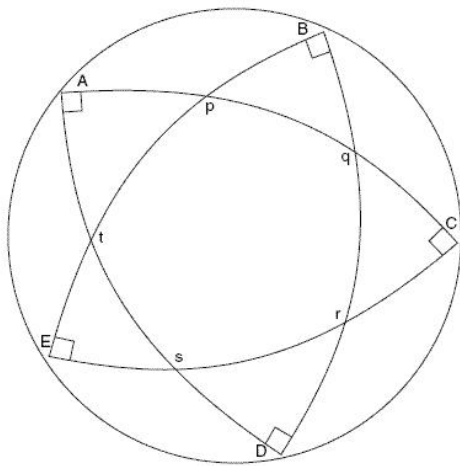


Figure 4. Pentagramma Mirificum

Gauss introduced the following expression $(\alpha, \beta, \gamma, \delta, \varepsilon)$
 $= (\tan^2 TP, \tan^2 PQ, \tan^2 QR, \tan^2 RS, \tan^2 ST)$ (4)

, where the following identities hold and three quantities can be determined by the remaining

two.

$$1 + \alpha = \gamma\delta, 1 + \beta = \delta\varepsilon, 1 + \gamma = \alpha\varepsilon, 1 + \delta = \alpha\beta, 1 + \varepsilon = \beta\gamma \tag{5}$$

Gauss gave a solution as $(\alpha, \beta, \gamma, \delta, \varepsilon) = (9, 2/3, 2, 5, 1/3)$ and also proved the following identity:

$$\alpha\beta\gamma\delta\varepsilon = 3 + \alpha + \beta + \gamma + \delta + \varepsilon = \sqrt{(1 + \alpha)(1 + \beta)(1 + \gamma)(1 + \delta)(1 + \varepsilon)} \tag{6}$$

, and area of polygon PQRST is given by, $APQRSTAPQRST = 2\pi - (|PQ| + |QR| + |RS| + |ST| + |TP|)$. (7)

7. Gaussian Function and The Gaussian Error Curve

Gauss introduced Gaussian (normal) distribution and demonstrated how probability can be represented graphically by a bell-shaped or a normal curve. This curve has the highest peak around mean and expected value and gradually falls off near plus and minus infinity. The graph of the normal curve is given below.

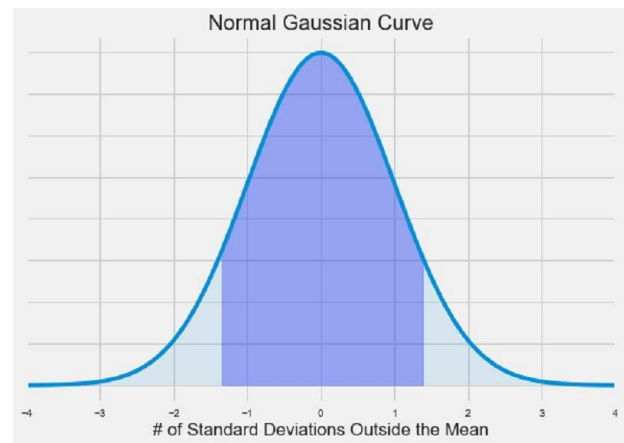


Figure 5. Normal Gaussian Curve

Also, Gaussian distribution is a type of continuous probability distribution for a real-valued random variable and the general form of the density function is given by,

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2} \tag{8}$$

8. Theorema Egregium (“Remarkable Theorem”)

Gauss’ Theorema Egregium is a result of differential geometry that talks about the curvature of surfaces. The theorem states that,

“The Gaussian curvature of a surface does not change if one bends the surface without stretching it.”

The Gaussian curvature K of a smooth surface in three-dimensional space at a point is the

product of the principal curvatures, k_1 and k_2 , at the given point:

$$K = k_1 k_2 \quad (9)$$

Thus, the theorem means that the Gaussian curvature can be determined entirely by measuring angles, distances and their rates on a surface, without reference to the particular manner in which the surface is placed, in the ambient 3-dimensional Euclidean space. The theorem is said to be remarkable because the result does not depend on its embedding even after undergoing all bending and twisting deformations.

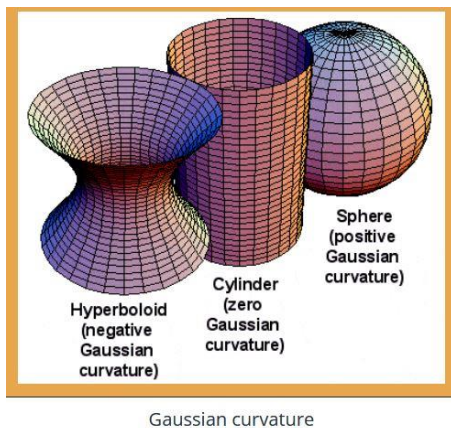


Figure 6. Gaussian curvature

9. Gauss-Ostrogradski's Theorem

Gauss theorem is also known as the Divergence theorem or Ostrogradsky's theorem. In vector calculus, this theorem states that, the surface integral of a vector field over a closed surface, which is called the flux through the surface, is equal to the volume integral of the divergence over the region inside the surface."

This theorem establishes a relationship between the flux of a vector field over a closed surface and the volume integral of the divergence of the field. Graphical representation of the Gauss theorem is given by,

$$\iiint_V (\nabla \cdot f) dv = \iint_S (F \cdot n) ds \quad (10)$$

10. Gauss' irreducibility Lemma

Gauss's lemma states that the product of two primitive polynomials is primitive (a polynomial with integer coefficients is primitive if it has 1 as the greatest common divisor of its coefficients). This lemma over the integers is stated as:

"If $P(X)$ and $Q(X)$ are primitive polynomials over the integers, then product $P(X)Q(X)$ is also

primitive."

Gauss irreducibility lemma states that:

"A non-constant polynomial in $\mathbb{Z}[X]$ is irreducible in $\mathbb{Z}[X]$ if and only if it is both irreducible in $\mathbb{Q}[X]$ and primitive in $\mathbb{Z}[X]$."

11. Gauss Approximation Method

Gauss had given Gauss-Siedel iterative method in numerical algebra used to solve a system of linear equations. This method is named after German mathematicians Gauss and Phillip Ludwig von Siedel. This method is used to solve a system of n linear equations with unknown X

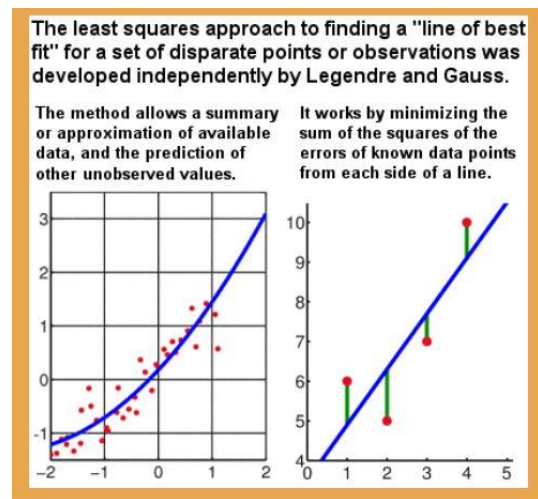
$$AX = b \quad (11)$$

and the iteration is given by:

$$LX_{k+1} = b - UX_k, \quad (12)$$

where X_k is the k -th approximation of X . A is decomposed into a lower triangular matrix L , and a strictly upper triangular matrix U , i.e., $A = L + U$.

12. THE LEAST SQUARES METHOD



Line of best fit by Gauss' least squares method

Figure 7.

13. GEODETIC SURVEY

In 1818 Gauss, putting his calculation skills to practical use, carried out a geodetic survey of the Kingdom of Hanover, linking up with previous Danish surveys. To aid the survey, Gauss invented the heliotrope, an instrument that uses a mirror to reflect sunlight over great distances, to measure positions.

In 1828, when studying differences in latitude, Gauss first defined a physical approximation of the figure of the Earth as the surface everywhere perpendicular to the direction of gravity (of which mean sea level makes up a part); later his

doctoral student Johann Benedict Listing called this the geoid.

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DANIEL BERNOULLI – A LIFE DEDICATED TO SCIENCE

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Abstract

Daniel Bernoulli, doctor, mathematician, teacher of metaphysics and natural philosophy, remained one of the most symbolic figures in the history of science. His name is commemorated by the equation he discovered, a specific example of the conservation of energy known nowadays as Bernoulli Principle. Friend but also rival of Leonhard Euler, Bernoulli is the author of some publications about hydraulics and mathematics. Just as importantly, he had abilities in other fields, earning a PhD in botany and anatomy and his master degree in philosophy. Our article is a journey in the private and professional life of the great Daniel Bernoulli.

Key words: Bernoulli equation, fluid mechanics, incompressible flow, kinetic energy, mathematics potential energy.

INTRODUCTION

Daniel Bernoulli was born in the city Gorningen, The Netherlands, on February 8, 1700 (Figure 1) (https://mathshistory.st-andrews.ac.uk/Biographies/Bernoulli_Daniel/pi-ctdisplay/) He is part of the Bernoulli Dynasty, a family of prominent mathematicians. Son of Johann Bernoulli, one of the early developers of calculus, nephew of Jacob Bernoulli, an early researcher in probability theory, with two mathematician brothers Nikolas and Johann II, Daniel was described by W.W. Rouse Ball as “by far the ablest of the younger Bernoulli’s”. He had a complicated relationship with his father who insisted that Daniel should be a merchant as his grandfather, a strategy that his own father tried with him. Daniel resisted to this idea and by the age of 13, Johann accepted this fact but refused Daniel being a mathematician so he decided that his son should study medicine. Their relationship didn’t become easier by the time past, reaching to compete for the first prize on a scientific contest. After this Johann forbade his son to come to his house and they remained argued until his dead.

Not surprisingly with such history in his family in mathematics, Daniel made rapid progress in this field although he also studied medicine. In this way, his career is based on many fields

having achievements in mathematics, medicine but also hydrodynamics. He is well known for the equation he discovered, known nowadays as Bernoulli Principle, which remained one of the most important findings from those times.



Figure 1. Daniel Bernoulli (1700-1782)

STUDIES

Having science running through his veins, Daniel was an excellent student gaining his baccalaureate in 1715 and his master's degree at Basel University in 1716. He respected the wish of his father and studied medicine at Heidelberg in 1718, Strasbourg in 1719 and then returned to Basel University in 1720. In return, his father was the one who thought him about calculates and mathematics. By 1720, his father had introduced Daniel to what would later be called "conservation of energy". In 1721, at the age of 21, Daniel Bernoulli graduated as a doctor with a thesis on the mechanics of breathing in which included a part of his soul passion, mathematics. Later on, he will be encouraged by the English physician, William Harvey - the first who observed that the human heart worked like a pump- to combine these two fields in order to discover the rules that govern the movement of fluids.

Apart from his usual abilities, Daniel studied the oscillation of air in organ pipes and defined the simple nodes and the frequencies of oscillation of a system. He showed that the movements of strings of musical instruments are composed of an infinite number of harmonic vibrations all superimposed on the string.

Bernoulli showed up a lot of interest in the Newton's theories and methods and using the principle of conservation of energy gave an integral of Newton's basic equation. He also studied the movement of bodies in a resisting medium using these methods (O'Connor and Robertson, 1998).

CAREER

After he took his PhD, Daniel hoped to get a job at Basel University with no success, but he continued to study mathematics in this time. In 1723, Daniel moved to Venice, Italy where he learned practical medicine. One year later, he received an offer from Empress Catherine I of Russia to teach mathematics at the Imperial Academy in St. Petersburg. Bernoulli hardly accepted the offer, mostly because his older brother, Nikolas, accompanied him but unfortunately, he died of tuberculosis the following year. From that time, Daniel was extremely unhappy and wanted to return home,

moment when his father sends there one of his students Leonhard Euler, who later will become not only friend of Bernoulli but also a rival. A temporary illness in 1733 was the perfect reason for Daniel to return to Basel University, where after a few failures he held successively the chair of medicine, metaphysics and natural philosophy until his death.

Although he was increasingly interested in the exact sciences, he began to publish a series of articles dealt with physiology. Two of his most important physiologic writings were treatises on muscular mechanics (1728) and the mechanical work done by the heart (1737) (Fye, 2009).

In 1738, he published his masterpiece named "Hydrodynamica", which includes all of his experiments and discoveries, his reputation being established after the publication of this book (Figure 2) (The Turner Collection, Keele University 1973).

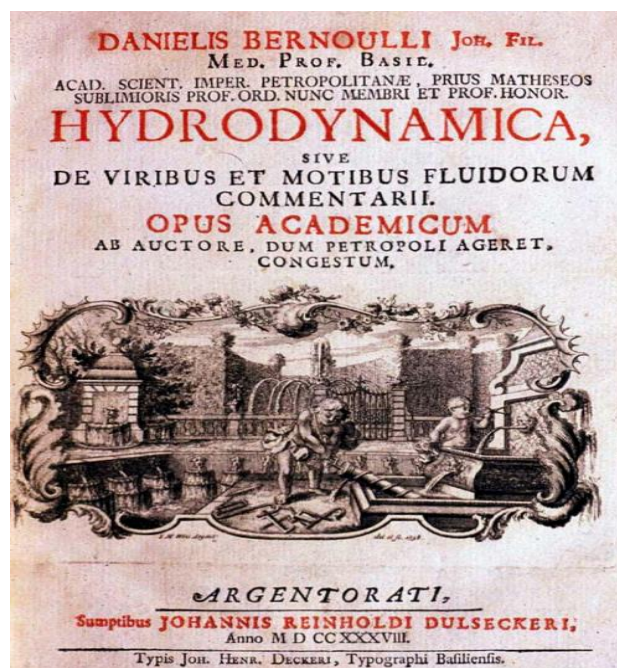


Figure 2. "Hydrodynamica" by Daniel Bernoulli

EXPERIMENTS AND DISCOVERIES

Bernoulli was a brilliant mind, showing a great ability in performing various experiments but also interpreting the results. All this journey in the world of experiments was accentuated by several people who encouraged him, one of the most important being Euler the one who refined Bernoulli's mathematics.

At first, Bernoulli tried to combine the two fields he activated, as he was advised and with Euler

were interested to discover more about the flow of fluids. More particularly, they wanted to know the connection between the blood speed and its pressure.

To investigate this, Daniel used as materials a pipe and an open-ended straw. He punctured the wall of the pipe and discovered that the height to which fluid rose up the straw was strongly correlated with the pressure of the fluid in the pipe (Quinney, 1997) (Figure 3) (The Turner Collection, Keele University 1973).

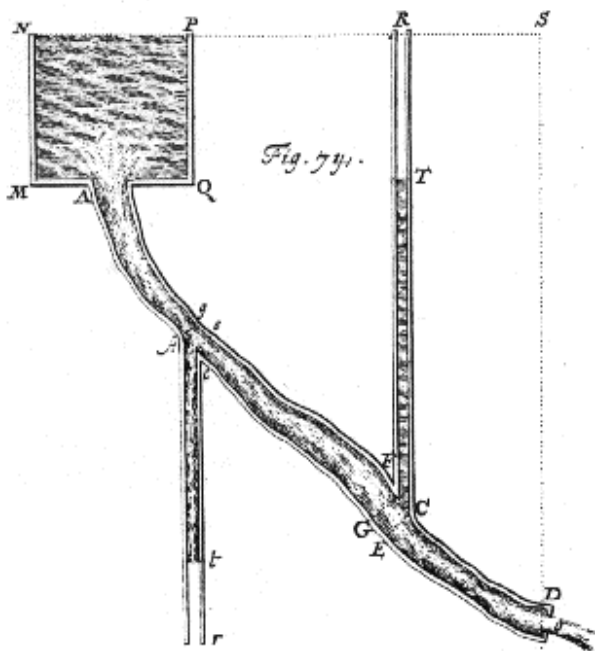


Figure 3. Bernoulli's diagram to illustrate how pressure is measured

This simple experiment didn't remain in the dark, so soon all the physicians were measuring patient's blood pressure by introducing point-ended glass tubes directly into their arteries. This practice remained valid until one Italian doctor discovered a less painful method, 170 years later. Although, this method of measuring pressure is still used in modern aircrafts to measure the speed of the air passing the plane. Surprisingly enough, Bernoulli wrote a paper in a totally different field from his usual abilities. In 1738, he published "Exposition of a New Theory on the Measurement of Risk", a work which included the idea that St. Petersburg paradox was the base of the economic theory of risk.

Bernoulli taught us to measure risk with the geometric mean and recommended minimizing

risk by spreading it across a set of independent events (bet-hedging). He also defined the situations in which one should avoid risk against the situations in which the risk should be chosen (Stearns, 2000).

Bernoulli noticed that when making decisions involving some uncertainty, people did not always try to maximize the monetary gain but most the utility. The paper influenced economic theory, portfolio theory and evolutionary biology.

Another discovery which could more be named an anticipation of James Clerk Maxwell work, the one who explained the origin of temperature, is *the kinetic theory of gases*. The kinetic theory relates the independent motion of molecules to the mechanical and thermal properties of gases. In chapter X of *Hydrodynamica* (1738), Bernoulli mentioned for the first time that gases consist of numerous particles in rapid random motion and he assumed that the pressure of a gas is produced by the direct impact of the particles on the walls of the container (<https://www.britannica.com/science/atom/Kinetic-theory-of-gases>).

Bernoulli's biggest merit was that he is the first who has explicitly established the kinetic origin of the pressure. Starting from the idea that the heat is the external manifestation of molecules' oscillatory motion, Bernoulli explains the pressure of the gas as a result of collision between molecules and cylinder's walls (Figure 4) (Cernica and Pasincovski, 2018).

In 1760 Daniel Bernoulli wrote an article related the smallpox. In his time there was much controversy around inoculation (the action of immunizing someone against a disease by introducing infective material, microorganisms, or vaccine into the body.), a practice that could protect people but could also be deadly. He showed that inoculation was advantageous if the associated risk of dying was less than 11% and that the inoculation could increase life expectancy at birth up to three years (Bacaër, 2011).

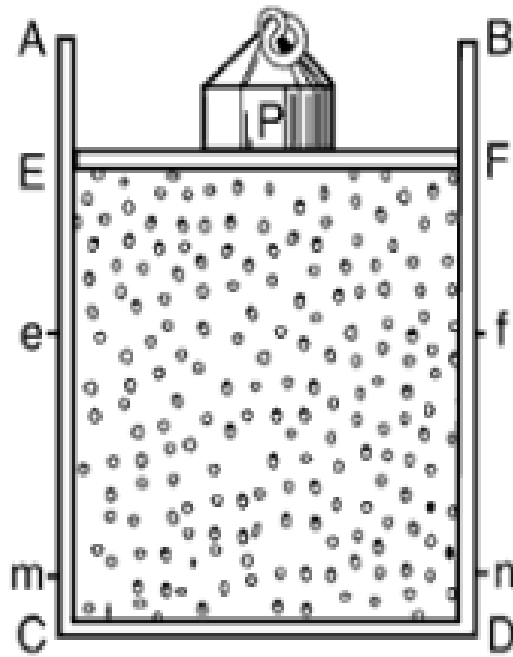


Figure 4. The pressure of gas according to Bernoulli

BERNOULLI'S EQUATION

Along all of these important experiments, the most valuable discovery that he made remain what we entitled today as Bernoulli's Principle. Bernoulli's equation is obtained by applying the principle of conservation of energy, according to which the variation of the kinetic energy of a system in a given time interval is equal to the sum of the mechanical work of the forces acting on the system in the same time interval.

Bernoulli's equation for steady frictionless flow written along a streamline, can be integrated between any two points 1 and 2 as

$$z_1 + \frac{p_1}{\gamma} + \frac{v_1^2}{2g} = z_2 + \frac{p_2}{\gamma} + \frac{v_2^2}{2g} \quad (1)$$

or can be write as general form:

$$z + \frac{p}{\gamma} + \frac{v^2}{2g} = \text{const.} \quad (2)$$

Each term in the equation (2) has the dimension of length and represents some kind of "head" of a flowing fluid as follows: z is the elevation head; p/γ is the pressure head; $v^2/2g$ is the velocity head (Cengel and Cimbala, 2006).

Bernoulli's theorem implies, therefore, that if the fluid flows horizontally so that no change in gravitational potential energy occurs, then a

decrease in fluid pressure is associated with an increase in fluid velocity.

Also, this equation can be written as a sum of specific energies:

$$zg + \frac{p}{\rho} + \frac{v^2}{2} = \text{const.} \quad (3)$$

We recognize gz as potential energy, p/ρ as flow energy and $v^2/2$ as kinetic energy, all per unit mass. Therefore, the Bernoulli equation can be interpreted as follow: the sum of the kinetic, potential, and flow energies of a fluid particle is constant along a streamline during steady flow when the compressibility and frictional effects are negligible.

However, it must be stated that the Bernoulli equation can be applied to solve different applications, taking into account the complete list of assumptions for Eq. (1): steady flow; incompressible flow; frictionless flow; flow along a single streamline; between 1 and 2 there are no pumps or turbines on the streamline; no heat transfer between 1 and 2 (White, 2014).

For real fluids, which have non-zero viscosity, Bernoulli's equation (1) also includes the term that quantifies the amount of head losses between the two sections:

$$z_1 + \frac{p_1}{\gamma} + \frac{\alpha_1 v_1^2}{2g} = z_2 + \frac{p_2}{\gamma} + \frac{\alpha_2 v_2^2}{2g} + h_{t1-2} \quad (4)$$

where a correction factor regarding the speed distribution in the section was noted with α , and the amount of load losses was noted with h_t .

Bernoulli's Principle shows up in a lot of different applications such as:

- To explain how plane wings generate lift.
- To explain how Bunsen burners work.
- Several different flow measurements rely on the equation such as the Pitot-static tube and the Venturi meter: if the fluid is flowing through a horizontal pipe of varying cross-sectional area, for example, the fluid speeds up in constricted areas so that the pressure the fluid exerts is least where the cross section is smallest. This phenomenon is sometimes called the Venturi effect, after the Italian scientist G.B. Venturi (1746 – 1822), who first noted the effects of constricted channels on fluid flow.
- He made fundamental contributions to hydrodynamics, including the basic principle

that allows airplanes to fly and that governs the design of sails and boat hulls.

OTHER SCIENTIFIC CONTRIBUTIONS

Daniel Bernoulli was a man of science, a special presence in the world of mathematics, hydraulics and medicine, having lots of publications and awards.

He never forgot about his big passion and in 1724 published "Mathematical Exercises" which includes four parts.

He won ten prizes from the Paris Academy of Sciences for different topics:

- In 1740 for works with Euler on Newton's theory of the tides.

- In 1743 and 1746 for essays on magnetism.

- In 1747 for a method to determine time at the sea.

- In 1751 for an essay on ocean currents.

- In 1753 for the effects of forces on ships.

- In 1757 for proposals to reduce the pitching and tossing of a ship in high seas.

He is part of the International Air & Space Hall of Fame at the San Diego Air and Space Museum, which commemorate people that have contributed to the advancement of aerospace flight, due to the fact that his method of measuring pressure was used to measure the speed of the air passing the plane.

He was elected as a fellow of the Royal Society. Bernoulli was the first who stated the principle of superposition in 1753, according to Leon Brillouin, a French physician.

He had a weighty contribution to the theory of statistics, being the first author who used the continuous method for solving statistical problems.

He was elected to most of the leading scientific societies of the leading scientific societies of his day including those in Bologna, St Petersburg, Berlin, Paris, London, Turin, Zurich and Mannheim.

CONCLUSIONS

Daniel Bernoulli (1700-1782) was born into a Swiss family of eleven famous scientists, being a virtual dynasty of that period but spent most of his life working at the Academy in Petersburg, where he produced 47 scientific works. Son of Johann Bernoulli, one of the eight gifted

mathematicians of the legendary family published his theory of hydraulics in his famous "Hydrodynamics" (1738), the most significant treatise on physical mechanics to appear in the 18th century. His theorem is the principle of energy conservation for ideal fluids in steady, or streamline, flow and is the basis for many engineering applications. He had lots of experiments, discoveries and publications in different fields making important contributions to science.

Daniel Bernoulli dedicated his whole life to science. He never gets married and had no children, although he had an attempt on getting married with a woman who turned out being very mean with money. He respected simplicity of lifestyle, living for his work. He passed away to eternity age 82 on March 17, 1782 in his sleep in Basel, Switzerland.

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<https://totallyhistory.com/daniel-bernoulli>