Project funded by EUROPEAN UNION

Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

PROCEEDINGS OF THE INTERNATIONAL CONFERENCE

"Protecting water resources with nature-based solutions - PS4S-2023"

May 24-26, 2023
Department of Forestry and Natural Environment Sciences.
International Hellenic University,
Drama, GREECE

Common borders. Common solutions.

Proceedings of the International Conference “Protecting water resources with nature-based solutions - PS4S-2023”

Editors: George N. Zaimes, Valasia Iakovoglou, Paschalis Koutalakis

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PROCEEDINGS

Organized by:

International Hellenic University

Editors:
George N. Zaimes
Valasia Iakovoglou
Paschalis Koutalakis

Editors Preface

The conference was organized by the Laboratory of Geomorphology, Edaphology and Riparian Areas (GERi Lab), Department of Forest & Natural Environment Sciences, International Hellenic University under the project “Protecting streams for a clean Black Sea by reducing sediment and litter pollution with joint innovative monitoring and control tools and nature-based practices" with the acronym "Protect-Streams-4-Sea" that is funded under the EU INTERREG IV “Black Sea Basin Joint Operational Programme 2014-2020”.

The Conference focused on the current developments on environmental and water management with an emphasis on innovation and new technologies to enhance its effectiveness and efficiency of nature-based solutions. It provided an opportunity for scientists, decision-makers and stakeholders to meet each other and discuss how to enhance environmental sustainability in the Black Sea region. This fact promoted the cooperation in environmental and water research and management among countries from the Black Sea Basin, the Mediterranean Basin, Europe and worldwide.

This conference coincided with the European Day of Parks 2023 (24th May 2023) "Building on our roots" & World Environment Day (5th June 2023) "Solutions to plastic pollution" and provided an avenue to celebrate these important days.

The scope of the conference was mainly to:

- Present new innovative environmental and water management methodologies
- Introduce demonstration projects on efficient and effective nature-based solutions
- Discuss recent advances in scientific research and technical development in regards sustainable water management and nature-based solutions
- Promote international collaboration for more sustainable water management
- Bring together scientists and practitioners from various parts of the world working on different aspects of environmental and water management

Participation was very encouraging with papers from 6 different countries and three continents, covering a wide range of topics. The topics of the conference were:

- Integrated water resources management
- Policies and governance related to water resources management
- Hydrologic modelling
- Remote sensing, airborne and GIS applications
- Groundwater and hydrological response under climate alterations
- Ecotourism, water resources and community well-being
- Water resources and sustainable ecosystems as relates to conservation, biodiversity and production
- Nature-based solutions and environmental protection
- Tools to assess environmental impacts and climate change effects (footprints, nexus approach, impact and risk assessment, life cycle assessment, etc.)
- Sustainable management of agricultural water and land resources •
- The urban water cycle and wetland parks
- Protected areas and geoparks
- Water quality and advanced technologies to facilitate industrial and municipal wastewater reuse

- Natural disasters – mitigation approaches in a changing climate (erosion, landslides, floods, etc.)

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SESSION II “PS4S-2023”- “PROTECT-STREAMS-4-SEA RESULTS I

Project funded by EUROPEAN UNION

Protecting streams for a clean Black Sea by reducing sediment and litter pollution with joint innovative monitoring and control tools and nature-based practices – "BS963-Protect-Streams-4-Sea"

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ABSTRACT

The Black Sea is considered one of the most degraded regional seas. Efforts have been made to improve the conditions of the Black Sea, but little focus has been on the inland pollutants and litter, specifically from the rivers and streams that end in the Black Sea. Streams and rivers are significant sources of sediment and litter. The study aimed to identify the primary sources of sediment and litter and their contributions. This will help to suggest the optimal nature-based solution to mitigate pollution sustainably. The study has five pilot areas in Greece, Romania, Armenia, Moldova, and Turkey. This will allow us to investigate different riverine ecosystems around the Black Sea and the implementation of different nature-based solutions. Surface and stream bank erosion methods are applied at different scales (plot and watershed) to estimate their contributions to the Black Sea. In addition, traditional (runoff plots erosion pins) and innovative methods (laser scanning, unmanned aerial vehicles) are utilized. This way, target areas with the highest erosion or litter will be targeted, and the optimal nature-based solutions based on the specific characteristics of these areas will be implemented.

Keywords: Non-point source pollutants, surface erosion, stream bank erosion, nature-based solutions, semi-enclosed sea

1 Introduction

The depollution of semi-enclosed seas is tricky because of the significantly slower water circulation since water can only be exchanged through narrow straights. The Black Sea is a typical semi-enclosed sea that circulates its water with the Mediterranean through the Dardanelles, Bosporus straits, and Sea of Marmara of Turkey. Therefore, it is considered one of the most polluted regional seas [1]. Major sources of pollution in the Black Sea are litter

and non-point sources (e.g., sediment and nutrients) [2, 3, 4, 5]. As in most seas, mitigating such pollutants has focused on marine or coastal environments despite rivers and their tributaries being major contributors [6]. Large rivers, such as Danube, Dnieper, Southern Bug, Dniester, Don, Kuban, Sakarya, etc., contribute approximately 300 km3 yr-1 of discharge to the Black Sea that is around 4-5 times the basin's surface area [1]. These waters carry many pollutants and are one of the reasons the basin experiences extensive anthropogenic pressures [1]. The project "Protecting streams for the clean Black Sea by reducing sediment and litter pollution with joint innovative monitoring and control tools and nature-based practices" with the acronym "Protect-Streams-4-Sea" will enhance environmental protection in the Black Sea by reducing its pollutants and litter. This will be accomplished by focusing on the inland pollutants and litter transported by the rivers to the Black Sea. In this paper, the major results from the five pilot areas are presented.

2 Study Area

Parallel activities are being implemented in five Black Sea region countries. The pilot areas in each country are a) the Aggitis River watershed in Greece, b) the Buzau River watershed and Siriu reservoir in Romania, c) Debed River watershed in Armenia, d) Baltata River watershed in Moldova, and e) Arhavi River watershed in Turkey (Figure 1). The pilot areas have water bodies with different characteristics to test the project methodologies in different Black Sea environments.

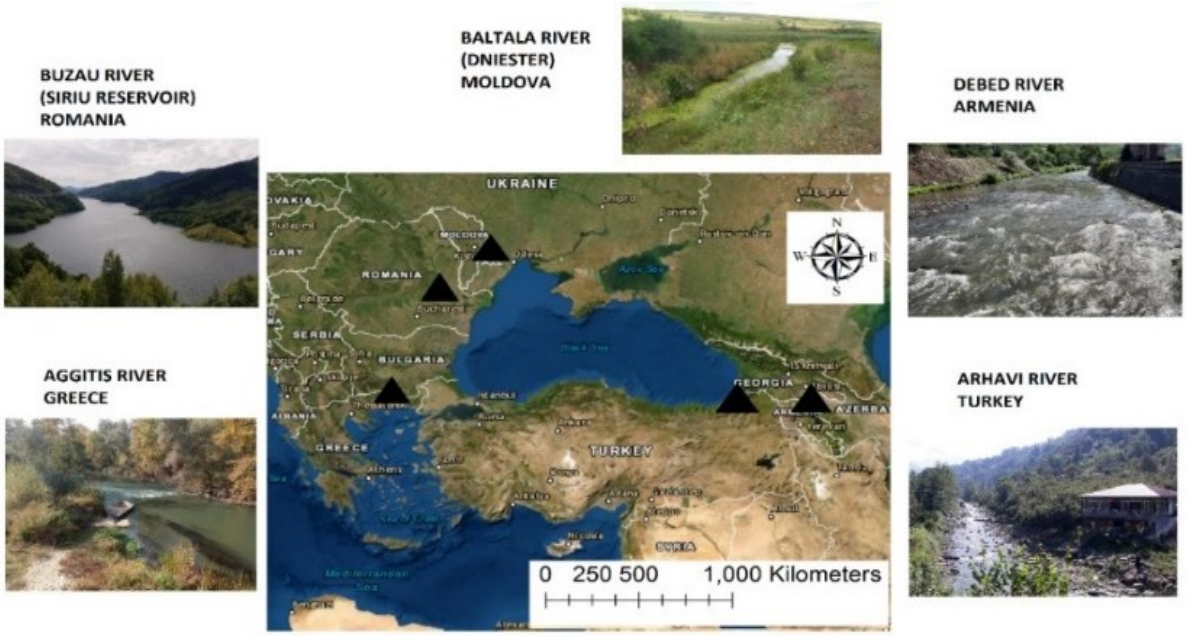

Figure 1. The project's pilot areas: Aggitis River watershed in Greece, Buzau River watershed and Siriu reservoir in Romania, Debed River watershed in Armenia, Baltata River watershed in the Republic of Moldova, and Arhavi River watershed in Turkey.

3 Methods and Materials

Traditional with innovative methods were utilized in this project to measure surface and stream bank erosion and microplastics. Specifically, at the plot scale, surface runoff plots and Gerlach traps were utilized for surface runoff and erosion pins, cross-section surveys, and laser scanning for stream bank erosion [7, 8]. To estimate surface and stream bank erosion at the watershed scale, remote sensing methodologies, geographic information systems, and hydrologic modeling were implemented [9]. Specific reaches were targeted, and images with Unmanned Aerial Vehicles (UAVs) were captured to produce orthomosaics and enhance the analysis quality of these areas [10]. Finally samples were collected to estimate the microplastics in selected water bodies.

4 Main Results

4.1 Greek Pilot Area – Aggitis Watershed – Detecting Geomorphological changes

Given the episodic and dynamic nature of river bank and bed erosion, along with the difficulty of reaching certain reaches, a methodological approach that uses aerial imagery from drones was developed and applied. Specifically, in the intermittent torrent channel Kallifitos in Greece two different flights (24 August 2022 and 23 October 2022) enabled us to capture the area in high detailed orthomosaics [10]. These products were analyzed and compared by developing the digital elevation model of differences—DoD (Figure 2). The methodology used was able to identify the location and the volume of the bed material extracted and the time frame in which it occurred. The comparison of the DoD showed that in area of 6329.41 m2 the volume of soil loss equaled to 5913.57 m3 (net loss). In contrast, in the area of 1658.70 m2, located at the west part of the captured image, a volume of deposits equal to 1032.91 m3 was deposited (net gained). The total extracted material was the subtraction of the previous numbers that resulted to 4880.66 m3. The specific stream reach "experiences" changes over time from natural geomorphologic changes but also from anthropogenic alterations.

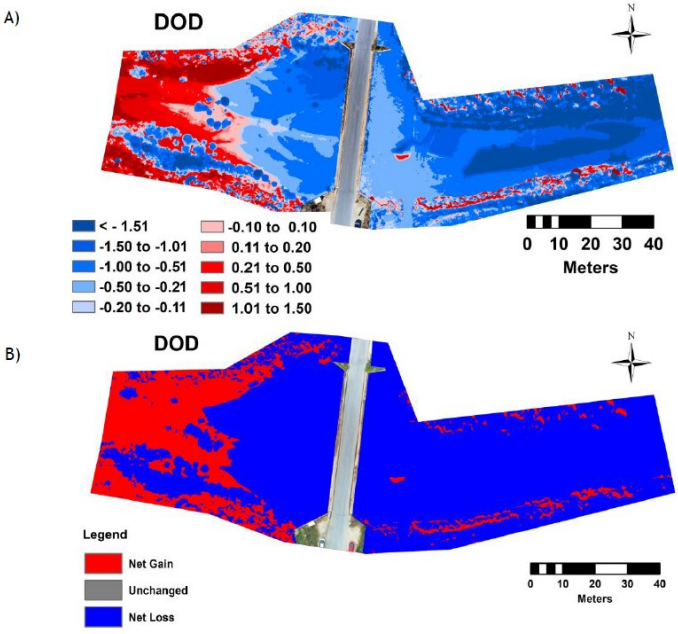

Figure 2. The DoD resulted from the comparison of the images between the dates 14 September 2022 (a) and 28 October 2022 (b). The colorized scale represents the different elevation categories (in meters). The 3 classes: (red) gained material, (grey) unchanged elevation and (blue) loss material.

4.2 Romanian Pilot Area – Siriu reservoir & Buzau River Basin - Microplastic

The study investigated the presence of the fraction of plastic below 5mm, called MICROPLASTIC, or invisible plastic, which is the most hazardous to the environment and human health. This study is the first study in Romania, carried out on water samples (Figure 3) (studying microplastic in suspensions) and sediment from a reservoir. The origin of this fraction is the fragmentation by degradation of plastic waste under the action of water, waves, UV radiation and temperature variation. Water and sediment samples were analyzed microscopically to determine the abundance and type of fragments in the samples. Fragments of plastic were identified in all the samples. Then, plastic fragments were selected for FT-IR spectrophotometric analysis, which determined the type of polymers present in the chemical structure. This represents a fingerprinting analysis, identifying the POLYMER from which that microscopic fragment is made. Thus, the origin of the plastic fragment (to which plastic object it belongs) is found.

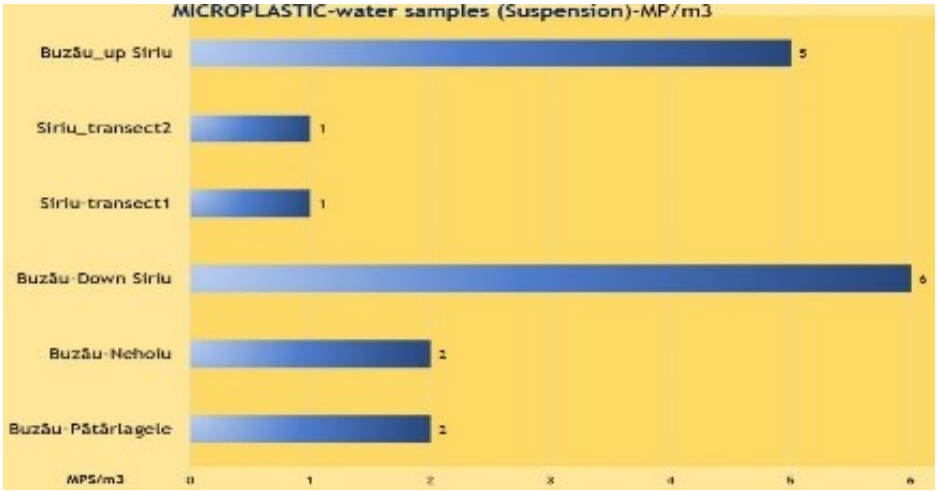

Figure 3. The microplastics in water samples collected in different location of the Siriu reservoir & Buzau River Basin.

4.3 Moldavian Pilot Area – Baltata River Basin – Soil and Steam Bank Erosion

The focus of the project main efforts in Moldova was due two factors: (a) the high degree of soil erosion and small rivers' extreme pollution caused by intensive agriculture and their bad monitoring, and (b) the almost complete lack of awareness and experience in using innovative monitoring and control tools in this field. The goal was using the Remote Sensing techniques was to identify the erosion-prone areas, utilizing historical satellite monitoring. Two tasks were addressed: the implementation of vegetation indexes to map areas that are the most vulnerable to soil erosion and use satellite images in the assessment of time trends in stream bank erosion. It was shown that above 8.4% of the Baltata River Basin is affected or exposed to erosion; the dominant erosion forms are landslides and gullies, occupying together 40% of erosion-prone areas. The time trends analysis highlighted a significant increasing trend in stream bank erosion (almost 80%), while very few sectors represented its decrease in 1985-2022 (Figure 4).

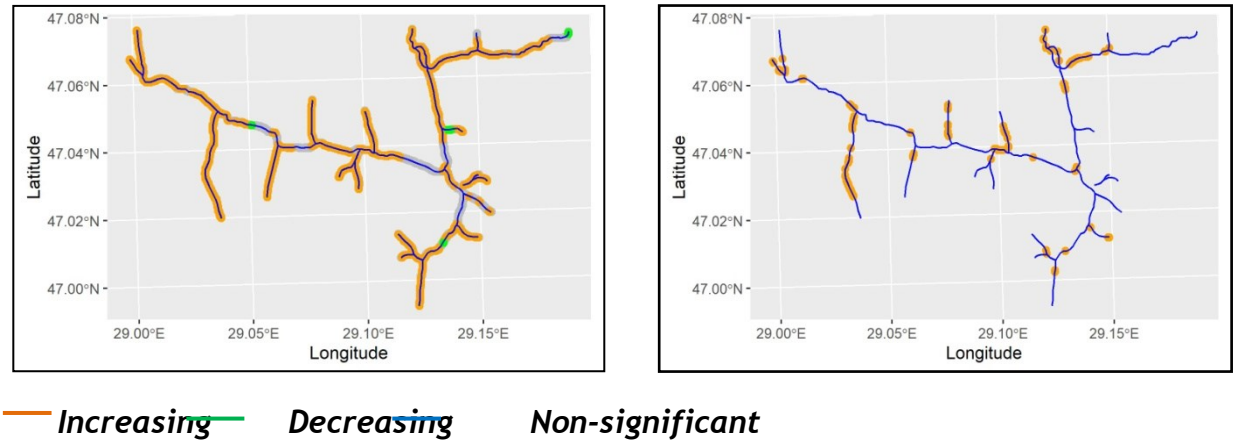

Figure 4. a) The Time trends in stream bank erosion of Baltata River, 1985-2022 and b) The sectors (in orange) within the Baltata River with a strong correlation between streams erosion and time.

4.4 Turkish Pilot Area - Arhavi River Basin – Stream Channel Changes

In this study the analysis was done on the lateral and vertical changes in the stream network of the Arhavi River Watershed in Turkey. The orthomosaics and the digital terrain model (DTM) were built for the study area, by collecting images with a UAV DJI Matrice 300 RTK and utilizing the Pix4DMapper structure-from-motion software. As the basis layers for digitization, topographic maps from the 1960s and Google Earth photos from 2011, 2015, and 2017 were used. ArcGIS 10.8 was used to define the centerline (thalweg), left and right banks, alluvial bars, and active channel width. The Channel Migration Toolbox was used to evaluate the lateral morphological change. The vertical changes within and along the stream were evaluated using the CloudCompare program (Figure 5) and show case both deposition and incision during the time period.

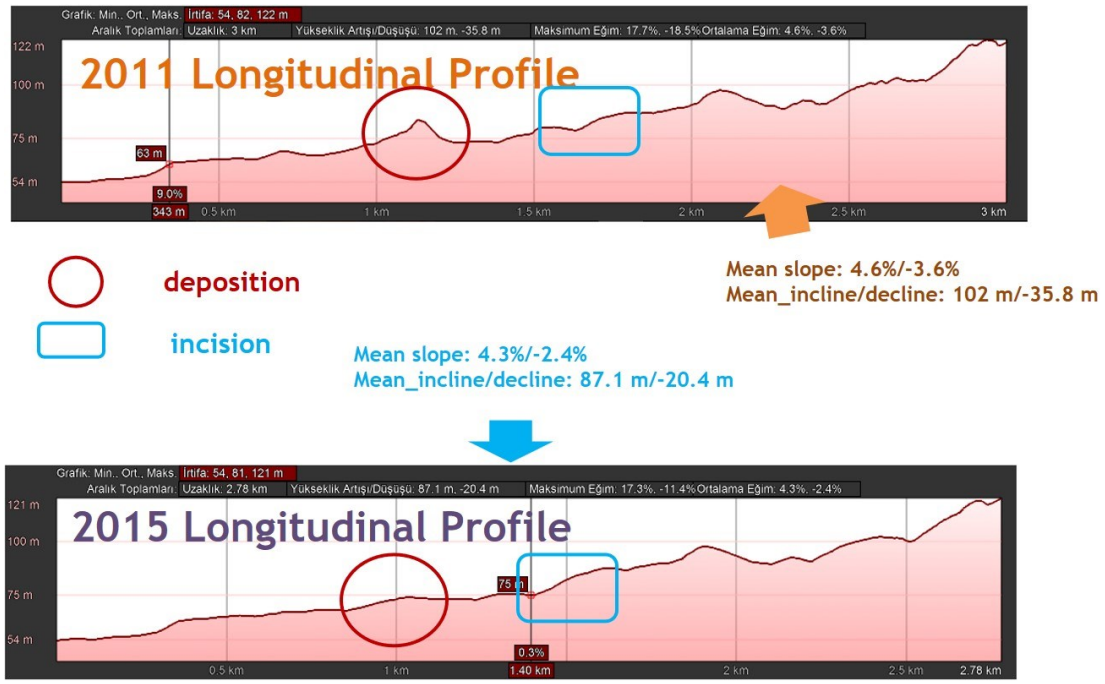

Figure 5. The longitudinal profiles dated in 2011 and 2015 showed that the average slope was 4.6% and 4.3% respectively. The mean incline was 102 m for 2011 and 87.1 m for 2015.

5 Conclusions

Nonpoint source pollutants are degrading and negatively impacting the Black Sea. Through this study innovative and accurate methods to asses surface and stream bank erosion. These methods provide accurate estimates of erosion and deposition at large scales but also showcase areas that are more vulnerable to erosion. This allows the water or land manager to implement targeted best management practices. In addition, the project addressed another important issue microplastics. These are a major pollutant problem in the region and measures need to be implemented to mitigate them.

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Investigation of macroplastic and microplastic fractions in Siriu reservoir and Buzău river course: the Romanian pilot case study – "PS4S-2023"

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ABSTRACT

This study aims to examine the composition and abundance of anthropogenic litter, of two sizes (macroplastics and microplastic) in an artificial lake and river system in Romania.The study area of Siriu Reservoir – Buzău River is located in the southern area of Eastern Carpathians, where upstream localities comprise a population less than 10.000 inhabitants; in the region low agriculture and tourism activities are reported. The study of litter (which also includes Macroplastic fraction) in the pilot area was based on the adaptation for inland waters of the the EU MSFD Guidance on Monitoring of Marine Litter in European Seas (2013) and Manual for the application of the classification system (2021). Plastics recorded the highest abundance (93%) of all litter. This category of items dominates in all sites, the biggest abundance being in Siriu lake. These have been identified 28 subcategories of plastic, the top 3 dominat categories were Plastic bottles, Plastic tableware (plates/cups/glasses/cutlery) and plastic fragments (size>2.5cm). According to the database, the plastic categories with the biggest abundance (over 65%) are those with a single use. There have been identified 10 categories of single-use plastics, the most numerous being plastic bottles (about 90%).Also, this study presents a pioneer research of microplastic pollution in an artificial lake – river system in Romania. In all samples, plastic particles were detected. Microscopic investigations on the samples conclude an average concentration of 3 particles per m3 of filtered surface water and an average abundance of 268 particles per Kg of sediment. In total, 4260 particles were counted. Most of the particles observed in both water and sediment samples are fibers (77.6%), followed by fragments (12.1%), foils (8,7%) and spherules (1.6%). Qualitative investigations using micro-FT-iR on several polycarbonate and fiberglass membranes identified the main presence of polyethylene, polypropylene, polyacrylonitrile and polyethylene terephthalate. On-field observations and MP characteristics determined a proximal source of the plastic pollution, as most of the identified particles were generated by macroplastics as bags, products related with domestic construction, vehicle tires and textile items.

Keywords: litter, macroplastic, The Clean Coast Index, microplastic, micro-FT-iR

1 Introduction

Many studies have shown that, rivers are the main bearer of plastics to the sea [1-4]. Wastes dumped illegally on river banks or brought from upstream during extreme events, continue their flow downstream in to the sea. (e.g., floods and rain, also enhanced by climate change) [5, 6]. The Black Sea is no exception, regarding the origin of a significant amount of macrolitter. In the studies on the amount of macroplastic on the beaches of the Black Sea, developed in 2019, within "Assessing the vulnerability of the Black Sea marine ecosystem to human pressures" (ANEMONE), the highest quantity was registered in Romania, followed by Turkey, Bulgaria and Ukraine [7]. Plastics made up the main share of litter on Black Sea coastal beaches near the river mouths (65-95%). Fragments and small plastic items were predominant for most of the beaches, including wild beaches and those that had lower levels of urbanization, confirming that riverine outflows have an important impact on plastic litter pollution on Black Sea coastal beaches [8].

A recent study about floating marine macrolitter (FMML) was assessed at the regional Black Sea scale for the first time, showing relatively high litter densities across the basin that reached a weighted mean of 81.5 items/km2 [9]. Current research in the field is moving towards "microplastics" (microscopic plastic eroded/weathered by sun, wind, waves). „Microplastic"(MP) refers to all particles smaller than 5 mm in diameter (most cannot be seen with the naked eye) [10]. Microplastics can affect not only the aquatic food chain (from the smallest planktonic organisms to large fish or aquatic mammals) but also the human food web.

These particles can accumulate in freshwater ecosystems such as lakes and rivers [11-13]. As a result of these studies, many rivers and streams are considered major sources of transport and accumulation of microplastics due to the proximity of their course to pollution sources such as urban or industrial areas [14]. Within freshwater systems, microplastic particles are present in the water column, in sediments [12,15], and also in certain species such as fish [16].

Considering that the main input of litters into the Black Sea are the rivers, we have aimed in this study, to identify litter accumulation hotspots, and classification of the main litter categories in the riparian zone of the pilot area. Also, the present study represents an unique and innovative research of MP pollution in an artificial lake – river system located in the southern part of the Eastern Carpathians. MPs concentrations were identified in water and sediment samples, additionally in sediment cores. The final aim of this study was an investigations of polimer type of MP fragments,using micro-FT-iR.

Knowing the sources of pollution, appropriate waste management strategies can be established. In a study area, plastic represents a pollutant that is present especially in the riparian area. In Romania, the European legislation on selective collection of waste has been transposed into legislation, BUT the illegal dumping of waste is still a current threat in Romanian rural regions due to improper waste management services. The rural population is not fully covered by waste management services, and selective collection is at an early stage. These conditions allow plastic from households to pollute the environment such as local rivers and lakes.

2 Materials and Methods

2.1 Study area

The study area is represented by the main course of the Buzău river from the border with Covasna county and downstream by the Pătârlagele locality, including the Siriu Reservoir. The Buzău river basin of the represents the basin of one of the most important tributaries of the Siret river from Danube basin, which flows into the sea in the northern part of the Romanian coast.

2.2 Sampling strategy

For Macroplastic study, a single sampling survey has been conducted from summer (July) to autumn (October) 2021. Three accumulation hotspots were established on the shorelines of Siriu Reservoir and five accumulation hotspots on the banks of the Buzău River (figure 1-a).

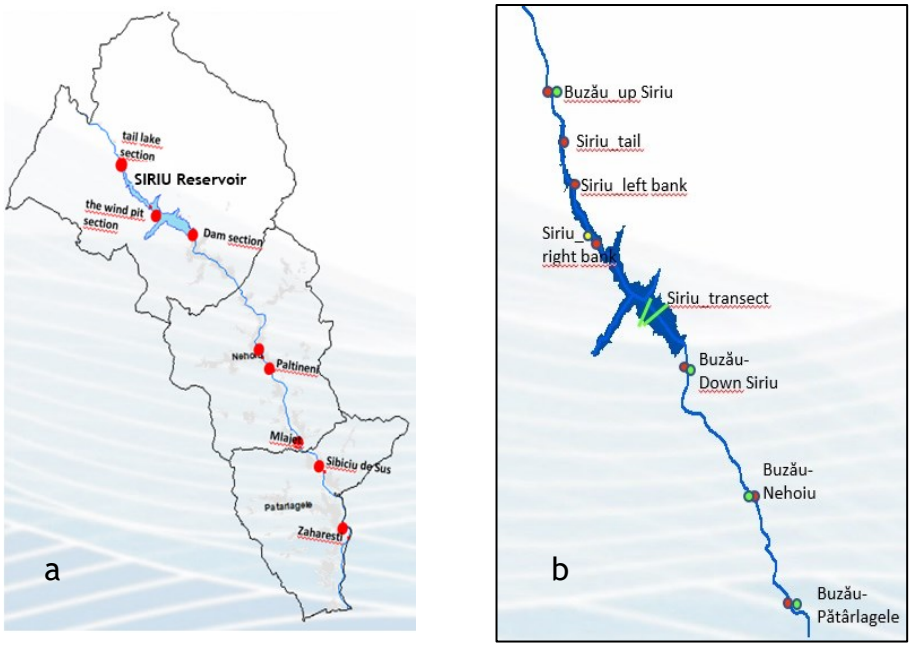

Figure 1 –Sampling point- a) Litter accumulation hotspots;b) MP sampling poits

For Microplastic study, sampling period coincide with the flood period (November 2022), high debits of the Buzău River permitting a representative evaluation of MPs. Therefore, 6 water samples, 7 sediment samples and 1 sediment cores were collected (figure 1-b). The sediments were sampled using an PONAR Grap or a stainless-steel spatula. The samples are represented by sand or siltic clay and were sampled from 1 location upstream the reservoir, 3 locations from the reservoir lake, and, 3 locations downstream the reservoir. Water samples were taken using a Neustonic net (Hydro Bios, 200µm, 40 x 70 cm frame), being collected from 1 location upstream the reservoir, 2 transects in the reservoir – in this case the net was attached to a motor boat, and 3 locations downstream the lake. The sediment cores, of 45 cm and 55 cm length, were collected from the northern area of the reservoir, the only location with unconsolidated sediment bed (siltic sand).

3. Results

3.1 Litter categories and abundance

The Macroplastic study was based on a visual analysis of the waste, according to the EU MSFD Guidance on Monitoring of Marine Litter in European Seas (2013) and Manual for the application of the classification system (2021) by adapting for inland waters (rivers and lakes). It is the first study carried out in our country on macrolitters. Lake and riverbank monitoring, similar to beach litter monitoring in the marine environment, comprises of the observation and the collection of litter items. In monitoring sessions, from July to October 2021, on the 8 sites a total of 15598 litter items recorded, removed and classified. It was a wide variety of categories and abundance. Collected waste belongs to 5 litter categories, 93% of waste is plastic (figure 2), 7% of litter representing metal, paper and cartons, glass and clothing. The highest abundance of litter was recorded in Siriu_right bank hotspot 7299 items (figure 3).

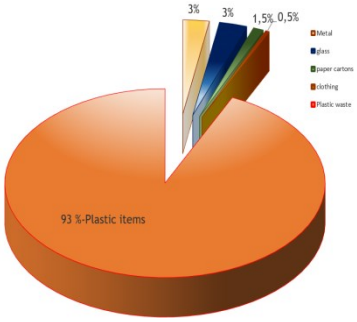

Figure 2- Litters type in study accumulation hotspots

Applying the The Clean Coast Index (CCI) [17], only one site was classified as “moderately clean”, the rest of 7 sites were classified as “dirty” and “extremely dirty”. According to Joint list of Litter Categories, the plastic and rubber items were classified into 28 subcategories. The top 3 dominat categories were Plastic bottles, Plastic tableware (plates/cups/glasses/cutlery) and plastic fragments: 2.5cm. Thus 60% of all plastic and rubber items were plastic bottles, followed by plastic fragments from breaking objects (8%), tableware, etc. The plastic categories with the biggest abundance (over 65%) are those with a single use. There have been identified 10 categories of single-use plastics and the most numerous were plastic bottles (about 90%).

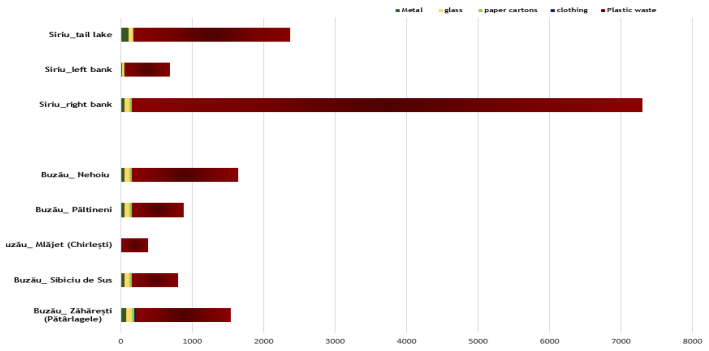

Figure 3- Abundance of litters in study hotspots

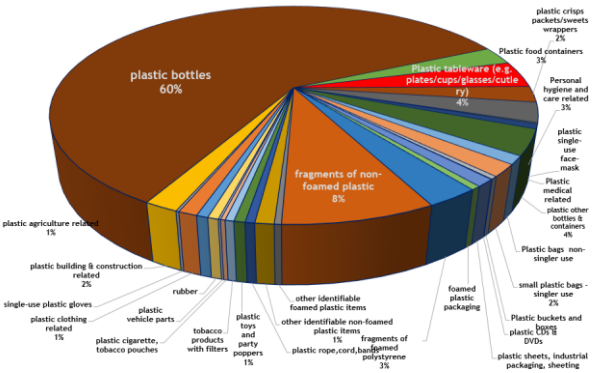

Figure 4- Plastic subcategories items

The wastes identified in the 8 accumulation hotspots are most likely from disposed illegally, tourism activities and litter produced inland and carried by winds, and torents as a result of poor waste management, agriculture sources and medical releted.

3.2 Microplastic study results

In all 19 samples for MPs study, plastic particles were detected. In total, 4260 particles were counted. In surface sediment sampled with Ponar gab, the average concentration of the superficial layer of Buzău River and Siriu Reservoir has been 268 particles/Kg and 235 particles/l. The highest density has been found in the upstream samples, especially in Siriu_tail site (445 p/Kg) and in the sediment samples in the middle of the lake (Siriu_left bank= 357 p/Kg and Siriu-right bank= 308p/kg). The MPs concentration decreases in the sediments of the Buzău river, downstream the dam, ranging between 190 p/Kg (Buzau_down Siriu) and 110 p/Kg (Buzau_Nehoiu) (figure 5).

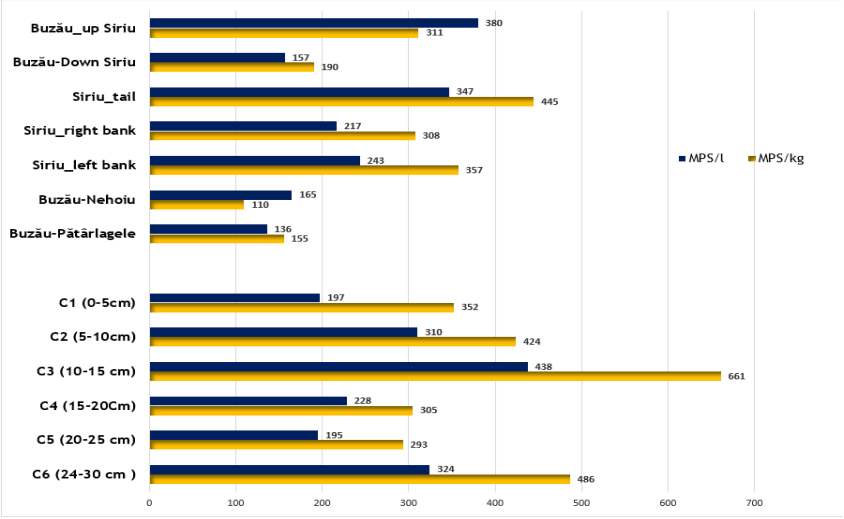

Figure 5- MPs in the sedimentary samples

Sedimentary core MPs identified in 6 intervals (C1 - top – C6 - bottom), each of 5 cm, have been deposit in the last 10 years according to an alternate depositional – erosion system, located in the northern area of the reservoir. The average concentration of MPs from the core is 420 p/Kg, but this is variable with sediment depth. The maximum concentration was identified in the cored interval 10-15cm (C3), with a value of 661 p/Kg, i.e. 437.5 p/L, and the minimum in the cored interval 20-25cm (C5), with a value of 293 p/Kg, i.e. 195 p/L.

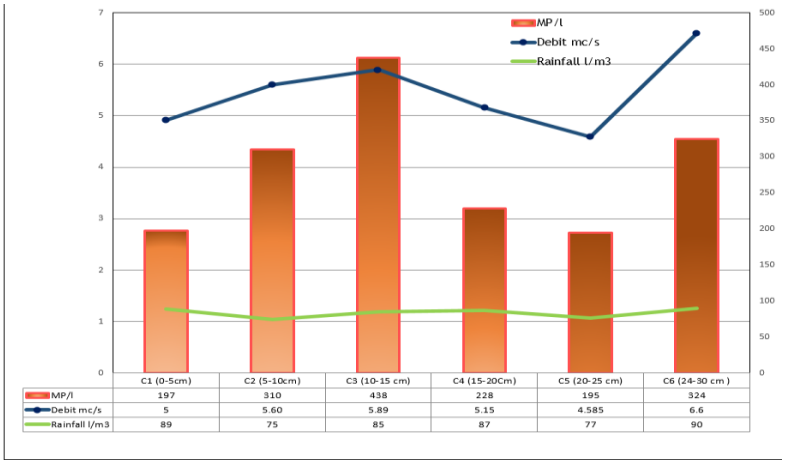

Figure 6- MPs in the sedimentary core samples

The distribution of MPs from the chronologically point of view possible corresponds with the amount of the debit of the Buzău River. For instance, the positive peaks represented by high abundancies of MPs can be associated with significant flood. The results obtained (figure 6) had a good correlation with the periods of high rainfall and high flows present in the last 10 years. In water samples, although particle abundance in the reservoir was identified with low values (transect samples: 0.6 – 1.1 p/m3), the MPs concentration upstream and downstream of dam, was found considerable higher, 4,5 p/m3 and, respectively 6 p/m3. At river sampling points lower concentrations of MPs were determined (Nehoiu, Pătârlagele 1.1 – 1.65 p/m3), decreasing the average abundance to 3 p/m3 (figure 7). Regarding the type of microplastic identified, the dominance of fibres can be observed in all water and sediment samples (figure 8).

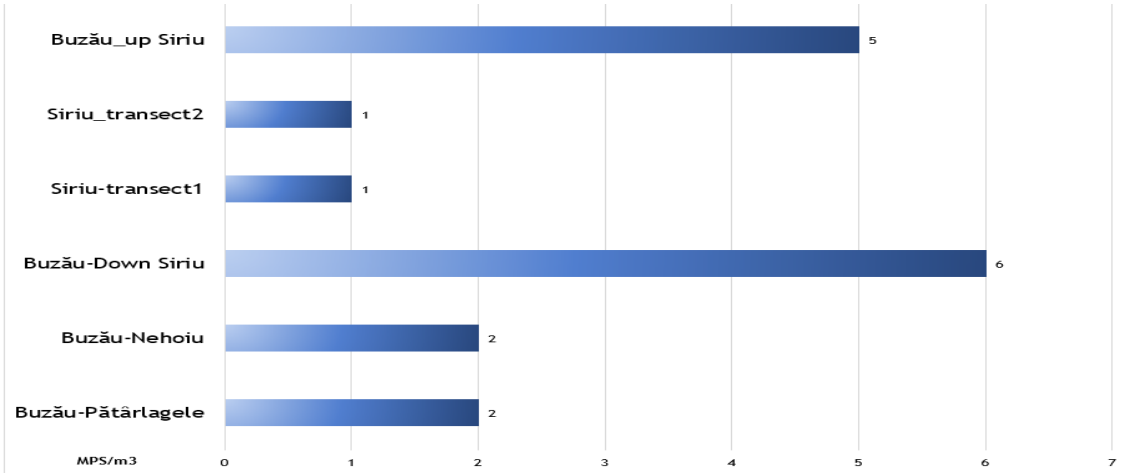

Figure 7- MPs in the water samples

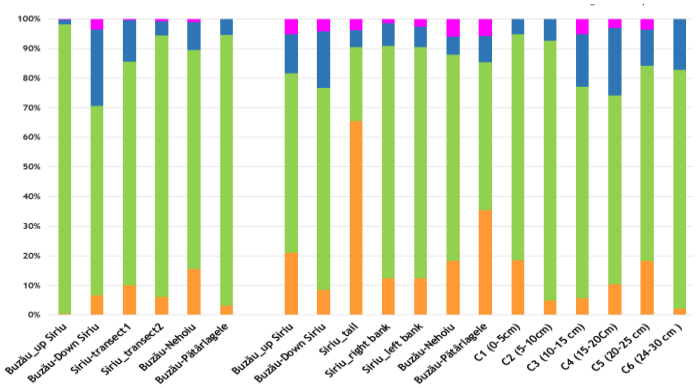

Figure 8- MPs morphology type

3.3 Polymer types

A total of 4960 particles were visually counted, from which 193 were tested through 30 spectrometric scans using the micro + FTiR spectroscopy, and 173 particles that have been identified as plastics (89.63%). The results were obtained by analysing 1-2 areas from each fiberglass membrane containing MPs concentrates. These show a dominant presence of polypropylene (PP, 28%), polyethylene (PE, 26%) and polyethylene terephtalate (PET, 19%). A low amount, i.e., less than 10% of the total MPs, was identified as PMMA, PS, PVC, and other elastomeric polymers. Most of the studied particles were foils (46%) and fragments (41%), being identified as PP (40%), PE (39%) and PET (18%). The fibers and spherules, were identified mainly as PE (35%), PP (24%), PMMA (20%) and PS (11%).

4. Discussion

The results of the Macroplastic study added up a total of 15598 litter items and the biggest abundance has been recorded in Siriu Reservoir (7299 items/100m). This is explained by the fact that the origin of the litter is located upstream of the lake, Siriu Reservoir representing only a receiver point for waste. The lower density of litter in the hotspots on Buzău river is explained by the fact that the sources are local, but the flow of the river, especially in the season with high flows, "cleans" the banks. Then litter reaches to Siret River which is tributary to the Danube and from there to the Black Sea.

Floating MPs from the surface water layer of lacustrine - riverine environment were identified with an average concentration of 3 p/m3. The highest concentration was identified in the Buzău River, upstream the Siriu reservoir, the minimum concentration being calculated in the southern area of the lake. Sedimentary MPs were found with the average concentration of 268 p/Kg, highest abundance being identified in the northern area of the reservoir and upstream of it. Thus, the concentration of MPs from both water and sediment samples indicates the hotspot accumulation points the area of entrance the river in the reservoir and especially downstream the dam.

Spectrometric results achieved by scanning areas of fiberglass membranes show a dominant presence of polypropylene (PP, 28%), polyethylene (PE, 26%) and polyethylene terephtalate (PET, 19%). Less than 10% of the total MPs are identified as PMMA, PS, PVC. As the main encountered morphology of MPs are fibers and films, and the dominant polymers identified are PP, PE, and PET, we assume that the sources of the MPs are located in the proximity of the sampling points. The amount of MPs originated from vehicle tires and textile products suggests

a low- to medium pollution from households and local roads, taking into account the aquatic high debits of Buzău River.

5. Conclusions

The present study contributes to the knowledge of waste accumulation hotspots, sources and type of waste present, the aim being to determine the type of behaviour of the population in the pilot area and adjacent areas, as well as the efficiency of the waste management system.This study shows how important it is to have a monitoring programs essential to control the leakage of waste into the environment and to make a good waste management practice, in order to reduce and to prevent waste that may end up in the marine environment. Moreover, raising public awareness, stimulating nature-friendly tourism, promoting cleaning and preservation campaigns on the shores of Lake Siriu and on Buzău River and a better coordination between institutions responsible for waste management is another important issue in this study. Although this study does not provide data on waste flow downriver, however it gives a picture of the sources of waste reaching the Black Sea.

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Application of WEPP model to assess soil erosion in Drama, Greece

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ABSTRACT

Streams in Greece have typical torrential flow and usually show a great potential of soil and streambank erosion as well as sediment and alluvial material delivery. The study describes the implementation of the Water Erosion Prediction Project (WEPP) model in order to assess the soil erosion rate in the watershed of Kallifitos torrent located near Drama City in the Regional Unit of Drama, Greece. The Kallifitos torrent is a typical Mediterranean torrent that after heavy rainfalls, the increased and intense streamflow enhances the streambank erosion while the water transports and deposits in different location huge amount of sediment, cobbles and pebbles. The results of the WEPP model also show the great sediment delivery in the studied catchment.

Keywords: runoff, hillslope, sediment yield, soil particles, soil erosion assessment

1 Introduction

Water resource management has been the subject of investigation and engineering for thousands of years, since humans started settling near water bodies [1]. Useful tools for its effective and efficient management are the hydrologic models. Hydrologic models include temporal and spatial features between water, climate, soil and land uses [2]. Today, there are many models describing water flow, water quality and ecology [3].

The Water Erosion Prediction Project (WEPP) model is a process-based hydrology and erosion model used by many researchers and land managers to predict surface runoff and soil erosion from croplands, rangelands, and forests [4]. The WEPP model simulates surface hydrology and hydraulics, subsurface hydrology, vegetation growth, residue accumulation and decay, and sediment detachment and transport along each hillslope and channel segment using four major input files: climate, slope, soil, and vegetation [5]. WEPP can simulate individual hillslope profiles, as well as small to large watersheds [6]. Detailed descriptions of each of the erosion processes simulated by WEPP are provided in Flanagan and Nearing [7].

The WEPP model has been in use for several decades and there exists a plethora of publications describing the model development and applicability to a wide range of management conditions for both croplands and forests. The wide application is proved by the development of several interfaces for the WEPP model such as GeoWEPP (Geo-spatial interface for WEPP), QWEPP (QGIS Interface for WEPP) [8]. In addition, the WEPPcloud is a new online interface for the WEPP model. WEPPcloud is complementary to the previously described WEPP tools, but it incorporates additional data sources [9]. WEPPcloud is open-source and has a full open-source modular software stack (watershed delineation and processing of climates, soils, and land covers are done independently of WEPPcloud), which can be coupled with other hydrologic models and decision-support tools such as the Rangeland Hydrology and Erosion Model [10]. Currently, WEPPcloud can be applied throughout the continental US, and beta versions are available for Australia and Europe [11]. The WEPPcloud was selected in order to simulate the hydrologic conditions and the

erosion/sediment ratio and yield in the Kallifitos torrent as a case study of the greater Aggitis Basin in Greece.

2 Materials and Methods

The first step in WEPPcloud is the hydrologic delineation. This step requires the digital elevation model (DEM) of the study area and based on the topography it enables the automatic delineation of the study area as a watershed, the hydrographic network and all sub-watersheds that are contained in the study area. The WEPPcloud contains the DEM for the territory of Europe so the user has to select the region of interest in order to create an initial hydrographic network and afterwards the user selects the exact location of the outlets of the watershed. The specific location is considered as the final selected case study and the software created the hydrographic network that discharges to that point, as well as the sub-watersheds of this area.

The Kallifitos torrent was selected as a representative example. The specific torrent ends up in the city of Drama and has been thoroughly studied with other methods and activities under the specific project [12]. The watershed area of the torrent is around 110 km2. It is a typical intermittent Greek torrent that has flash flood risk potential after heavy rainfalls [13]. The flow can change in hours from no flow to a flow with great rapidity, carrying large amounts of water, sediments and debris [14]. Its headwaters start at Falakro Mountain, continuing its flow nearby the Kallifitos Village while it crosses through chutes under the city of Drama and finally discharges to Agia Barbara Stream, a tributary of Aggitis River [15]. The Aggitis River Basin is surrounded by different mountains. Specifically, to the west by the Menoikio Mountain, to the east by the Falakro Mountain to the southeast by the Ori Lekanis Mountain and to the southwest by the Paggeo Mountain [16]. The central section of Aggitis River Basin is cultivated for cereals such as wheat and barley and as you move further downstream with maize and cotton. The lowlands of the studied torrent are varied in bed width, channel slope, bank heights and slopes, with a meandering pattern and several anthropogenic interventions as it flows through the city of Drama [17]. The studied torrent reach is of high importance due to its proximity to Drama City, the fact that it causes frequent flooding and damages the road network and the Irish bridge and disrupts the city's transportation. The torrent has a diversity of fluvio-geomorphologic changes in its channel and bed shape with large amounts of sediment transported, deposited and eroded during and after heavy rainfalls.

The location that was selected corresponds to the following extent coordinates (UTM Zone: 35 UTM Upper Left: 254087.0, 4581382.0): 24.06071730475099 (xmin), 41.11271073476463 (ymax), 24.371457589452117 (xmax), 41.34641031488657 (ymin) and the center (longitude, latitude): 24.216087447101533, 41.22966494387527. The final outlet coordinates (lon, lat): 24.157577595382772, 41.14575192218151 with Pixel Coordinates (x, y): 295, 902. Distance between requested and actual: 0.0 m. The sub-catchments delineation resulted to 412 channels (Figure 1.a) and 927 hillslopes (Figure 1.b) in an area of 11000 ha.

The slope/aspect categories were resulted based on the topography/DEM (Figure 2.a). The WEPPcloud contains the Europe's NATURA land use types that correspond to (Figure 2.b):

- Forest, coppice with coverage 72.5%
- Wasteland, shrub with coverage 23.5%
- Arable land, cereals with coverage 4.0%

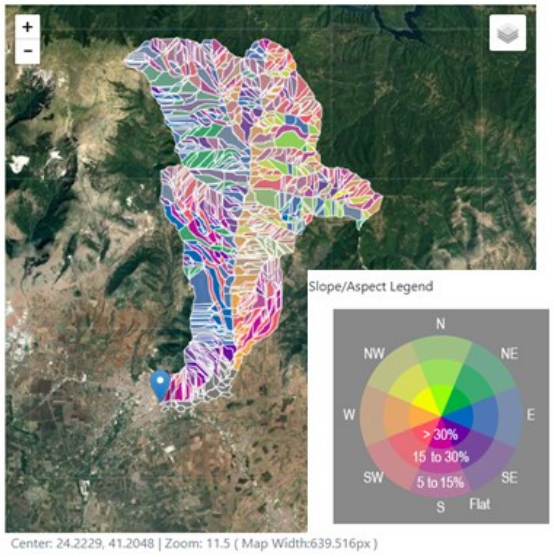
The WEPPcloud also includes the soils for the entire territory of Europe that were determined per hillslope (Figure 2.c). The WEPPcloud provides many weather stations for the European Union. Based on the coordinates of the location, the data used in the current case study were generated by CLIGEN at watershed centroid based on the closest station) in Romania Turnu Magurele (ROE00100905), Location: 24.88, 43.75 and Elevation: 31.0896 m. The generated climatic data were the following (Table 1):

- Average Annual Precipitation (Pmean): 440 mm
- Average Monthly Air Temperature Max (Tmax): 18 °C
- Average Monthly Air Temperature Min (Tmin): 7.3 °C

A

B

Figure 1. a) the stream network and b) the sub-watersheds of Kallifitos watershed.



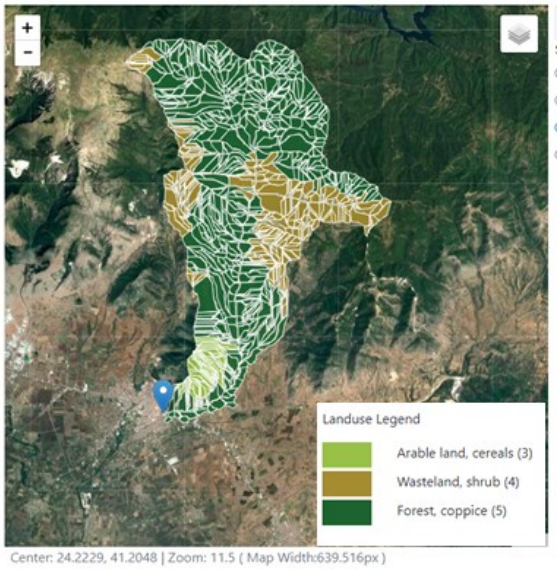


Figure 2. The a) slope map, b) the landcover and c) the soils of Kallifitos watershed.

Table 1. The generated monthly average values of weather station.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
P_{mean}	42	37	41	34	41	34	19	24	28	41	47	53
T_{max}	5.7	7.9	12	17	22	26	29	29	25	18	12	7.4
T_{min}	-1.7	-0.65	1.8	5.9	10	14	16	16	12	8.1	4	0.14

The following parameters were used as default values to run the model:
•Rain Snow Threshold Temperature (C): 0.0
•Density of new snow (g/cm3): 100.0
•Snow Settling Density (g/cm3): 250.0
•Initial groundwater storage (mm): 200
•Baseflow coefficient (per day): 0.04
•Deep seepage coefficient (per day): 0
•Watershed groundwater baseflow threshold area (ha): 1
•Critical Shear (N/m2) based on Median Channel Bed Particle Size (mm): CS = 19.0
•Channel Erodibility (s/m; 1e-6default): 1e-06
•Minimum value of channel critical shear (taumin) limit, N/m2: 35.0
•Maximum value of channel critical shear (taumax) limit, N/m2: 70.0
•Curve parameter k: 0.02
•Curve parameter n: 1.0
•Evaporation and Transpiration (ET): Penman-Monteith's equation
•Climate Method: E-OBS Modified (Europe)
•Spatial Mode: single climate station
•Years of Simulation: 100 years

3 Results & Discussion

The overall results of the WEPP model are presented in Table 2. The following graph (Figure 3) illustrates the daily runoff (blue), the daily lateral flow (green) and the daily baseflow (orange) for the 100-year period as extracted by the WEPPcloud model. The average annual sediment discharge from outlet is 120 ton/yr. The average annual sediment delivery from hillslopes is 65 ton/yr. The sediment particle class information leaving channel is from the watershed loss file (Table 3). The outlet class distribution and soil component distributions are also from the watershed loss file. The hillslope statistics are aggregated

from the hillslope pass file and the soil components are calculated based on the class information leaving the channel (Tables 4 and 5).

Table 2. The average annual delivery from channel outlet for years 1-100.

	From outlet	Per unit area of watershe
Total contributing area to outlet	11000 ha	
Precipitation	46000000 m^3/y	442.1 mm/yr
Stream discharge	2300000 m^3/y	22.02 mm/yr
Total hillslope soil loss	65 ton/yr	6.2 kg/ha/yr
Total channel soil loss	99 ton/yr	9.4 kg/ha/yr
Sediment discharge	120 ton/yr	11 kg/ha/yr
Sediment delivery ratio for watershe	0.723	

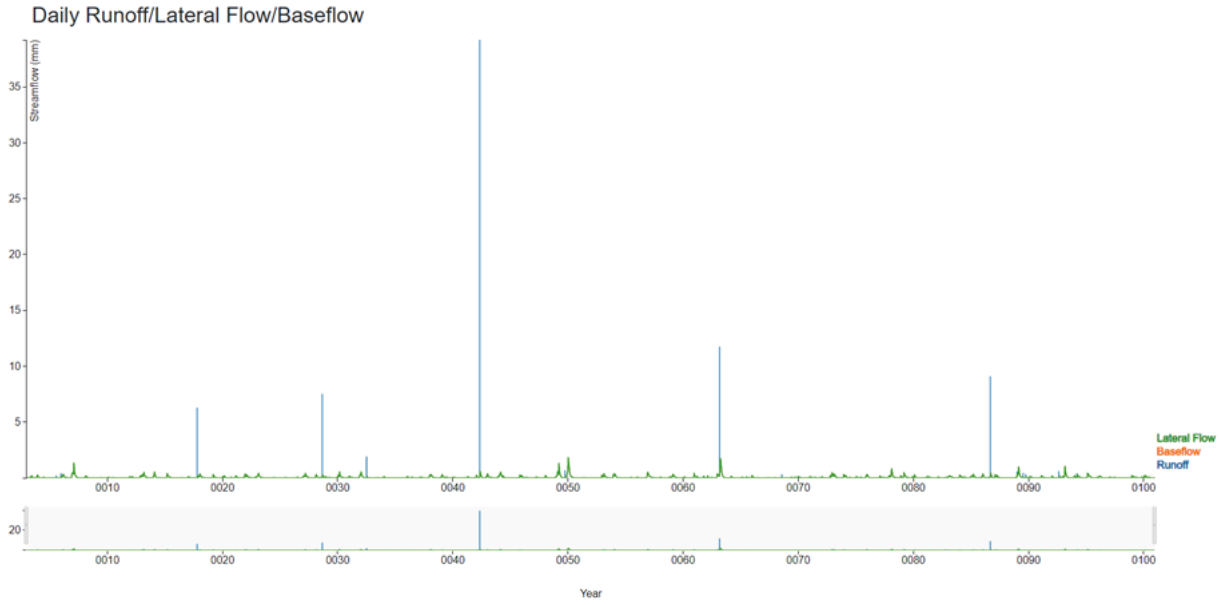


Figure 3. The daily runoff/lateral flow/baseflow.

Table 3. The sediment particle class information leaving channel

Class	Diameter (mm)	Specific Gravity	% Sand	% Silt	% Clay	% OM
1	0.002	2.600	0.0	0.0	100.0	42.9
2	0.010	2.650	0.0	100.0	0.0	0.0
3	0.030	1.800	0.0	78.9	21.1	9.0
4	0.300	1.600	79.7	10.4	9.9	4.2
5	0.200	2.650	100.0	0.0	0.0	0.0

Table 4. The distribution by sediment class.

Class	Fraction at outlet sediment class distribution	Fraction at hillslope sedimer class distribution
1	0.036	0.041
2	0.214	0.361
3	0.221	0.236
4	0.314	0.276
5	0.216	0.086

Table 5. The distribution of primary particles and organic matter.

Type	(Fraction outlet)	(Fraction hillslope)
Clay	0.113	0.118
Silt	0.421	0.576
Sand	0.466	0.306
Organic Matte	0.048	0.050

4 Conclusions

Reliable models for simulating water flow and sediment discharge from watersheds are needed for proper land management. WEPP, a process-based, continuous erosion prediction model, was adapted for forest watershed applications. Specifically, a modern version (the WEPPcloud) was utilized in the Kallifitos watershed; an area which is a representative small watershed for the entire pilot area of Aggitis Basin and is also frequently monitored by field measurements. The results highlighted intense sediment delivery in the studied catchment. The comparison of WEPP model results from for the Kallifitos watershed, showed that the model can simulate the soil loss very effectively. With this study, it is thought that soil losses occurred due to the land use status of the watershed, topographical structure (being a slope land as a general structure) and that the land use is the most important effect that made a difference in terms of sediment yield. In this study, the WEPPcloud capabilities were presented with a simple example, so that, the land manager can use it in their field of interests.

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SESSION III “PS4S-2023”- “Protect-Streams-4-Sea Results II”

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

Integration of GIS technologies in RUSLE method for estimation of susceptibility to erosion in Baltata River's basin

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ABSTRACT

Within the framework of the BSB963-PS4S project "Protecting streams for a clean Black Sea by reducing sediment and litter pollution with joint innovative monitoring and control tools and nature-based practices", an analysis of the level of annual erosion in the Baltata river basin, situated in the central part of Moldova, was carried out by integrating GIS into the classical RUSLE method, using spatially distributed data on soils types and their granulometric properties, precipitations characteristics, topography, vegetation and land use. The model estimated annual soil losses in the range from 1 to 31 t/ha/yr, 82.6% of the territory has low and very low erosion susceptibility. The highest values of soil loss pertain to the areas that are used for row crops and have the steepest slopes.

Keywords: GIS, RUSLE, Annual Soil Loss, Erodibility, Erosivity

1 Introduction

The Universal Soil Loss Equation by Wischmeier& Smith (1), 1978 was used [6], which was also designed to assess soil erosion risk in Europe [8], and Castravet [9] based his study of Middle Prut Plain area on his approach as well.

$$A=R*LS*K*C*P \quad (1),$$

where A – is mean annual soil loss; R – rainfall erosivity factor; K – soil erodibility factor; LS – topographical factor, i.e soil length and soil steepness factor; C – land cover and management factor; P – conservation practice factor (P=1 in our model, e.g. no conservation practices). It was used in Moldova in the 1980s on experimental plots by Dobrovolsky [5].

2 Methods

Object of research - the Baltata River, one of the right tributaries of the Dniester, belongs to the numerous small rivers in Moldova. The area of the basin is 153.9 km2, the length from northwest to southeast is 27.47 km, and the width is 7.74 km. From the northwest it adjoins the river basin. Ichel, from the south - the river basin. Bic, and from the north and east the basins of other small rivers - tributaries of the Dniester. The relief is predominantly flat. Absolute marks vary from 16 m to 219 m, 120 m on average. Surface

slopes, from sub-horizontal to steep, average 40. The object of study is described in more detail in [21].

For calculating the R-factor, we had monthly precipitations and maximum diurnal precipitations data for 2020 for the 15 meteorological stations, acquired from State Hydrometeorological Service. We used several approaches [3, 10, 11, 12,13, 14] in order to determine the best one suitable for the conditions of our territory, used the Arnoldus's MFI index, and the correction formula by Castravet [3] afterwards.

The C-factor in the RUSLE equation ranges from 0 to 1, where 0 is soil cover completely preventing erosion, and 1 is soil without any cover, comparable, for example, to tilled bare fallow. Erencin Zihni [15] did an extensive study on C-factor mapping from satellite images by land cover classification, and even demonstrates a table of C-factor values from literature reviews. The second approach to C-factor mapping is to use NDVI and then recalculate it according to De Jong [16] formula: C=0.431 – 0.805*NDVI (2).

We tried both of these approaches, but ultimately decided to use the first one since it provided more accurate results for the territory in study. After converting land use shapefile into raster, we used the resample procedure in order to obtain grid file with resolution of 10 meters for the model.

The soil type shapefile was extracted from the 1:700000 soil map by Ursu and Overchenko [17], who correlated soil taxa in Moldova with soil taxa in the FAO classification; and the data on soil particle size distribution, humus content, soil structure code and permeability rating were taken from [18]. We used the formula (3) to calculate the K-factor.

$$K= (0.00021(12-MO)M^{1.14}+3.25(S-2) +2.5(P-3))/100 \quad (3),$$

Where, K – soil erodibility factor; M=(%silt+%very fine sand)(100-%clay); MO – organic matter content in soil; S – soil structure code;and P – soil permeability rating. L and S factors in USLE equation represent the impact of topography on soil erosion [19, 9]. They were estimated from 1-arc second (30 meters) DEM of Baltata River basin, which was resampled to 10 meters resolution. The formula (4) was calculated by ArcGIS Map Algebra and Hydrology and Surface toolsets.

$$LS=1.4(U/22.13)^{0.4} * ((sinB)/0.896)^{1.3} \quad (4),$$

where U – flow accumulation grid; B – slope grid.

3 Results

The resulting RUSLE model for the project area allows us to estimate stream banks susceptibility to erosion. According to the model's results, annual soil losses in the area range from 0 to 151.77 t/ha/yr, with the highest values pertaining to the areas of the steeper slopes and used for row crops, and the lowest – to the valleys and thalwegs. We had used the classification of ICPA (1987) [20] for our model, which ties in the values of annual soil washout with the susceptibility to erosion:

- 0-1 t\ha\yr – very low;
- 2-8 t\ha\yr - low;
- 9-16 t\ha\yr moderate;
- 17-30 t\ha\yr high;
- >31 t\ha\yr very high susceptibility.

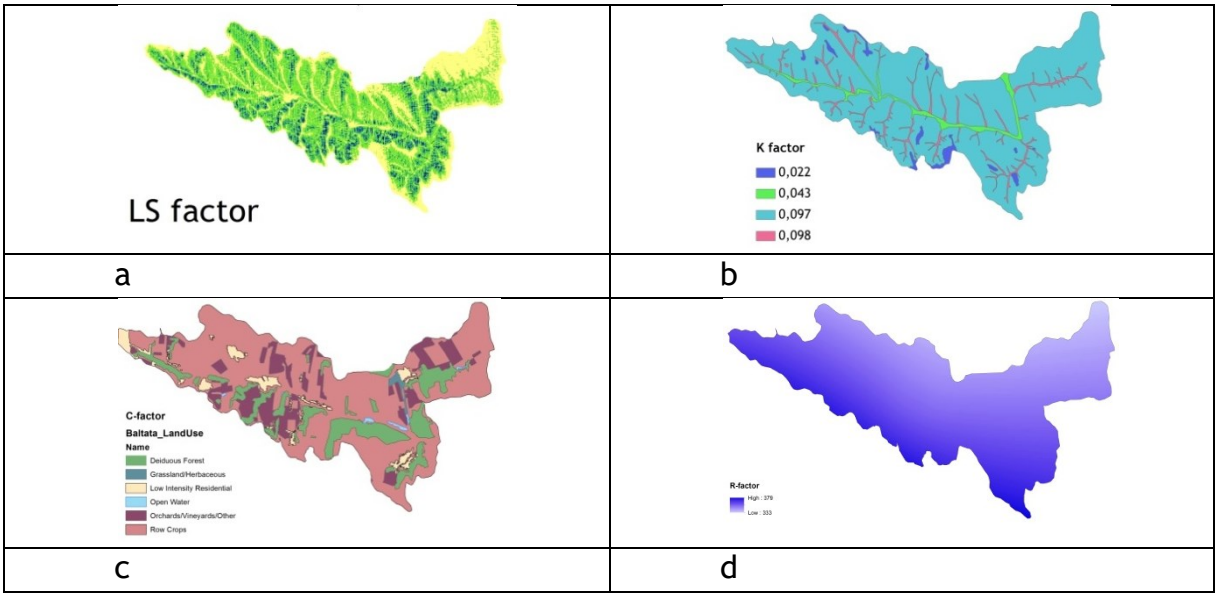

Figure 1. Baltata river basin, spatial distribution for LS factor, dimensionless (a), K-factor, (tons*ha*h)/(7.59*ha*MJ*mm) (b), C-factor, dimensionless (c), and R-factor, (Mj*mm)/(ha*h*yr) (d)

The left bank of the Baltata River has the largest share of steep slopes in the entire river basin, however, due to the fact that the same area accounts for most of the extended areas with forests, as well as half of the orchards and vineyards of the basin, the annual loss of soil under these plantations is quite small (0 - 8 t/ha/yr). At the same time, where the protective effect of the vegetation cover is absent, we observe the most prone to erosion zone (to the south of the village of Baltata).

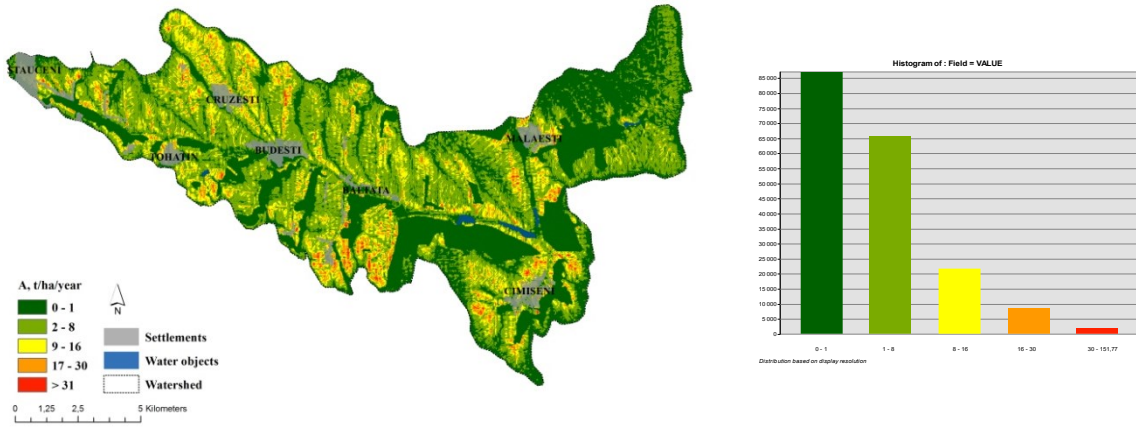

Figure 2. Mean annual soil loss

Histogram for the erosion susceptibility classes (fig. 2) demonstrates, that 82.6% of the area of Baltata River basin are comprised by areas with low and very low erosion susceptibility (<1- 8 t/ha/year), which can be explained by the fact that areas with the largest slopes or the largest runoff in many cases fall on forested areas in the Baltata River basin, which neutralizes the effect of erosion.

4 Discussion

In the context of climate change, leading to more frequent and intense natural disasters, soil erosion and the resulting degradation of the soil cover in the Republic of Moldova has been and remains an urgent problem that requires adequate monitoring [1]. In addition to reducing soils' fertility, this process also leads to pollution of tributaries of large rivers with heavy metals and organic residues, which, in turn, pollutes the Black Sea basin. Although dry spells have become more frequent over the past decade, excessive rainfall, which is the main cause of the erosion process, has also become more frequent in the whole country and in the study area [2, 3]. As for the resulting effect of rainfalls that produce erosive events, the most dramatic changes occured in the villages of Balabanesti, Cruzesti and Tohatin, where the share of moderately eroded soils had increased by at least 10% over the period of 16 years [4].

A more detailed raster with land use types, as well as the use of daily precipitation to calculate the R-factor, can significantly improve the model. In addition, the use of anti-erosion measures and their consideration as a P factor for assessing the dynamics of annual losses of soil volumes per hectare is of interest for further research. The model can also be used to estimate changes in erosion rates when land use changes, such as deforestation.

5 Conclusion

GIS methods provide opportunities to estimate mean annual soil losses' spatial distribution on a regional and basinal level. The obtained results of GIS RUSLE model correlate with the data on erosion levels within the area in study. The conducted studies allow creating a more accurate monitoring system by improving the erosion observation network.

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

Using SWAT model to estimate the water yield in Aggitis River Basin, Greece.

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ABSTRACT

The soil and water assessment tool (SWAT) is a well-used hydrologic modeling tool that has been implemented in diverse hydrologic and environmental conditions to investigate the available water resources. This study assesses the hydrologic phases in the Aggitis River Basin. The SWAT daily streamflow results after being calibrated and validated were very good.

Keywords: hydrologic regime, streamflow, sediment yield, water yield, water balance

1 Introduction

The Soil and Water Assessment Tool (SWAT) model is considered as one of the top hydrological models [1]. SWAT is also a free tool with many available assisted software and data to be used as inputs. For this reason, SWAT was selected to determine the hydrologic regime of the Aggitis Basin. This activity is essential in order to find the potential pollutants sources at the watershed scale.

2 Materials and Methods

The first level of the hydrologic basin's subdivision is the sub-basin. Subbasins possess a geographic position in the watershed and are spatially related to one another [2]. The land area in a subbasin may be divided into hydrologic response units (HRUs). HRUs are portions of a sub-basin that possess unique land-use/management/soil attributes. The benefit of HRUs is the increase in accuracy it adds to the prediction of loadings from the sub-basin. A sub-basin will contain at least one HRU, a tributary channel and a main channel or reach. One reach or main channel is associated with each sub-basin in a watershed [3]. Loadings from the sub-basin enter the channel network of the watershed in the associated reach segment. The term tributary channel is used to differentiate inputs for channelized flow of surface runoff generated in a subbasin. Tributary channel inputs are used to calculate the time of concentration for channelized flow of runoff generated within the sub-basin and transmission losses from runoff as it flows to the main channel [4].

The first step in SWAT model is the Watershed Configuration which is based on the topographic data [5]. The Digital Elevation Model (DEM) of the entire pilot area was used as input data (Figure 1.a). The DEM was acquired from the European Environment Agency datasets updated on 11 December 2017 (DEM cell size 25X25). The spatial reference of the required datasets (DEM, hydrographic network, landcover, soils and slope) was in WGS84_UTM_Zone_34N (Geographic Coordinate System WGS_1984). The projection was done at Transverse Mercator. The selected outlet point was the location of Simvoli Dam. The proposed threshold values were included (Area: 3000 ha and Number of cells: 37054) in order to create the flow direction map and the flow accumulation map and finally define the DEM-based stream network. This process created the DEM-based stream network, the outlets, the

sub-basins (35 sub-watersheds) and the entire basin (185107.79 ha) as presented in Figure 1.b.

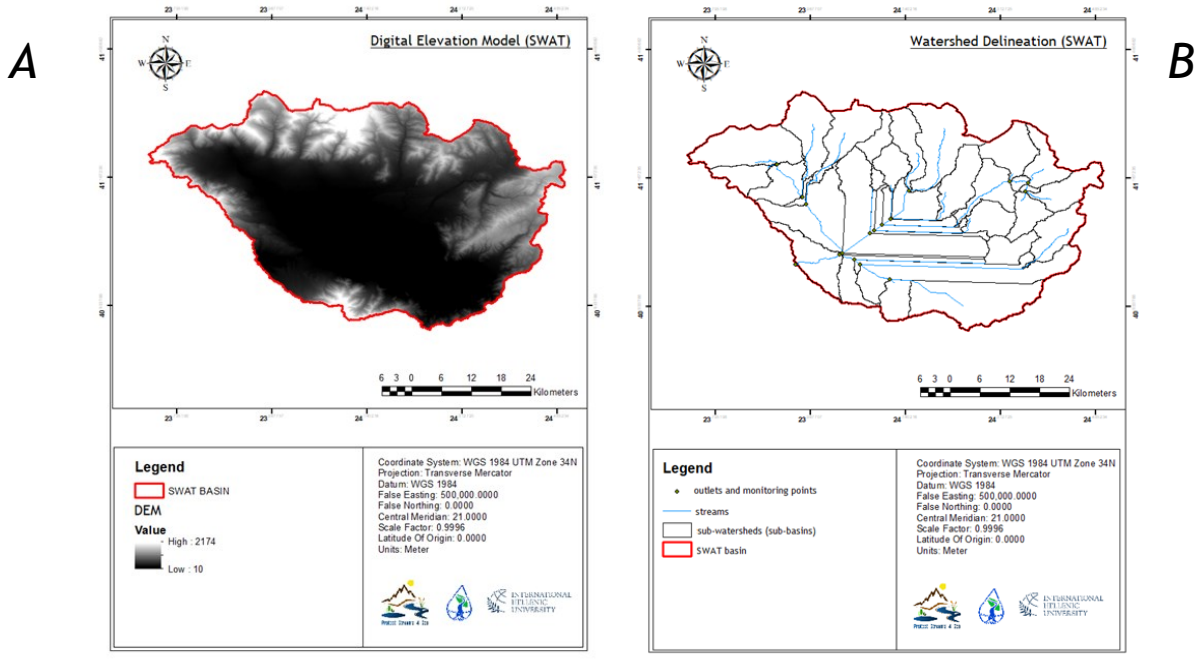


Figure 1. a) the basin and digital elevation model (DEM) and b) the sub-watersheds, streams, outlets and basin of Aggitis.

The next step is to create the Hydrologic Response Units (HRUs) which are unique combinations of landcover, soil and slope in each sub-watershed [5]. The slope map of the area is depicted in Figure 2.a. Slope classes were three based on the DEM's statistics: i) 0-10% (75777.01 ha or 40.94%), ii) 10-50% (88412.67 ha or 47.76%), and iii) >50% (20918.11 ha or 11.30%). Landcover dataset was acquired from the European Union Copernicus Land Monitoring Service (Corine 2018). The SWAT model includes a United States of America database [6] but is uses a different description for the landcover types, so a transformation was required. Table 1 reports the SWAT codes and the description while Figure 2.b represents the SWAT land-use map. SWAT incorporates a US-based soil database. This database is impossible to be used for the European Union territory. The soils for the Greek pilot area were inserted in the SWAT's database based on the Harmonized World Soil Database (Figure 2.c). This database provides most of the parameters that are required in order to rung ArcSWAT. The HRUs were created based on the threshold of 0%. This means that each category (e.g., soils) must have a coverage ≥0% at the overall watershed in order to be included in the HRU definition. This means that all land-use categories, soil types and slope classes included. This step resulted to 1541 HRUs (Figures 2.d).

Table 1. The landcover used as SWAT codes and their description.

SWAT code	Description	SWAT code	Description
URHD	Residential High Density	CRGR	Mosaic cropland/grassland
URMD	Residential Medium Densi	AGRC	Agricultural land close grown
UCOM	Commercial	FRSD	Forest Deciduous
UTRN	Transportation	FRSE	Forest Evergreen
URLD	Residential Low Density	FRST	Forest Mixed
URBN	Residential	GRAS	Grassland
AGRL	Agricultural land generi	MIGS	Mixed grassland/shrubland
AGRR	Agricultural land row cro	RNGB	Range brush
GRAP	Vineyards	SHRB	Shrubland
OLIV	Olives	BARR	Barren
PAST	Pasture	BSVG	Barren or sparsely vegetated
		WATR	Water

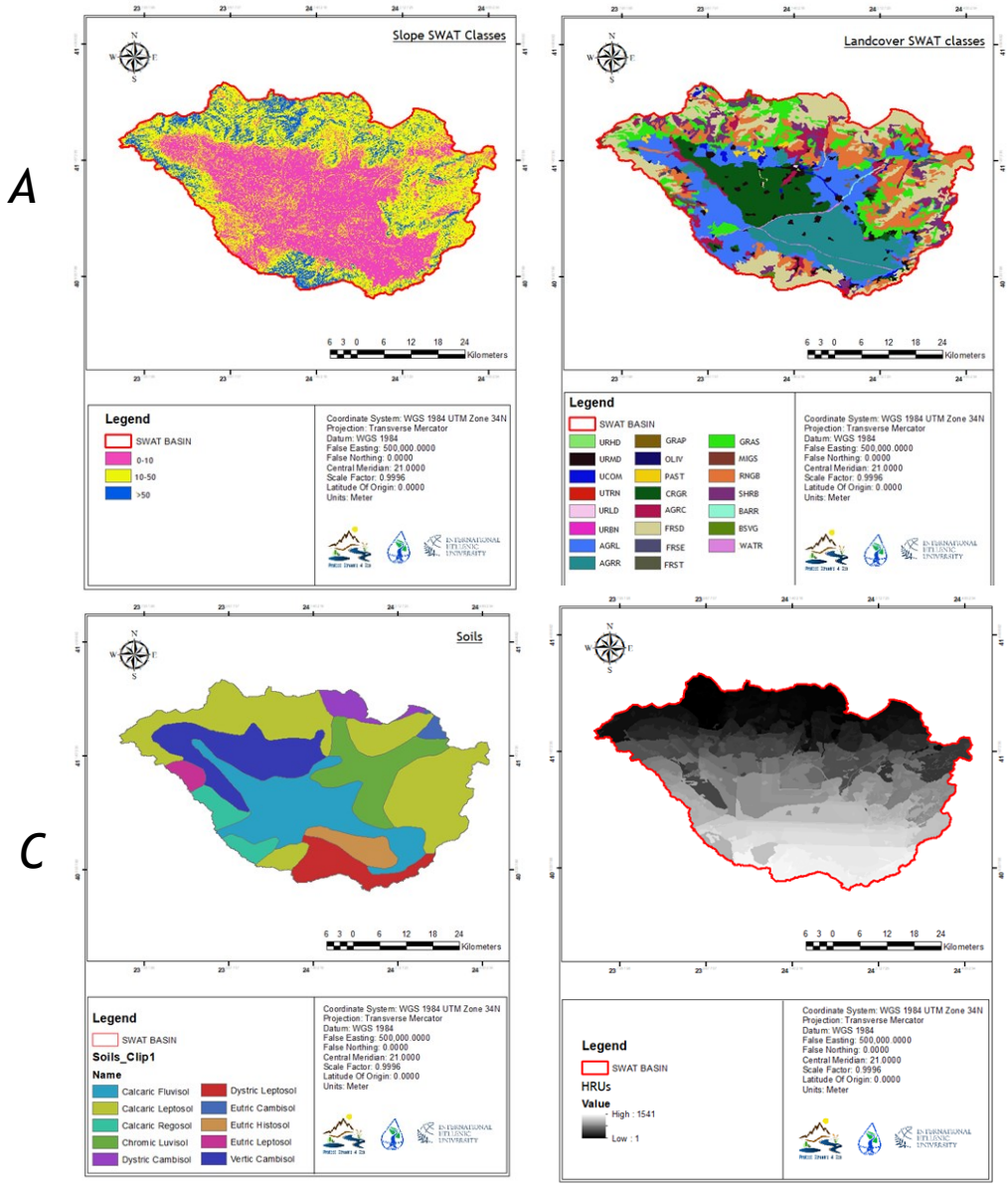


Figure 2. The a) slope map, b) the landcover, c) the soils and d) the Hydrologic Response Units (HRUs) of Aggitis Basin.

SWAT requires daily precipitation (in mm), maximum/minimum air temperature (in °C), solar radiation (MJ/m2), wind velocity (m/s) and relative humidity (fraction) [7]. Values for all these parameters may be read from records of observed data or they may be generated. The weather generator input file contains the statistical data needed to generate representative daily climate data for the subbasins. Ideally, at least 20 years of records are used to calculate parameters in the .wgn file. Climatic data will be generated in two instances: when the user specifies that simulated weather will be used or when measured data is missing. Daily weather datasets (precipitation, minimum/maximum temperature, relative humidity, solar radiation and wind velocity) were downloaded from the Global Weather Data for SWAT database (https://globalweather.tamu.edu), for the stations of Asprovalta, Emmanouil Papas, Serres, Nevrokopi, Filippoi and Sitagroi. In addition, data retrieved from the Micropoli Weather Station (Owner: International Hellenic University funded and installed from 2013 by the EU Black Sea Program Streams-2-Suppress-Fires) and from online datasets by a local weather station (Mavrovatos). All variables were available for the stations used (except the solar radiation for the Mavrovatos and the Micropoli stations).

Finally, a model cannot be applied without statistical analysis of its reliability. In general, the coefficient of determination (R2) and Nash-Sutcliffe Efficiency (NSE) are the most popular statistics used to evaluate the performance of the SWAT model [8]. The simulated datasets were calibrated based on recorded data of streamflow (m3/s) from the installed telemetric hydrologic station in Simvoli (Figure 3). This process resulted to satisfactory fit based on the NSE (Nash-Sutcliffe efficiency) that was equal to 0.55, RMSE (root mean square error) was very good equal to 7.51, PBIAS (percent bias) was also very good equal to 4.76.

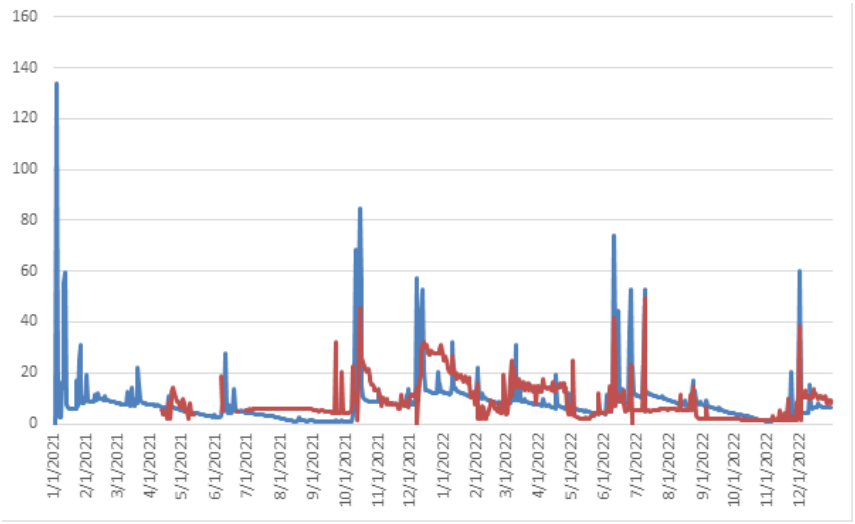


Figure 3. The simulated (blue line) and the recorded water discharge by the installed telemetric hydrologic station in Simvoli Bridge (Aggitis River).

3 Results & Discussion

The period simulation was from 01-01-1979 to 31-12-2022 and different simulations used in a daily, monthly and yearly step. The final simulated results of the water balance are presented in Figure 4. Evapotranspiration (ET) is almost half portion of the total precipitation falling in the Aggitis Basin. This is due to the high percent of natural vegetation and agricultural areas occupying the basin. Direct surface runoff is 16% representing a dense hydrographic while lateral flow and groundwater flow and storage are also important phases in the Aggitis Basin represented by 7% and 30%, respectively. Figure 5 includes the average

monthly values of precipitation (PREC), surface runoff (SURQ), lateral flow in the soil (LATQ), groundwater discharge (GQW), percolation (PERC), soil water content (SW), evapotranspiration (ET), potential evapotranspiration (PET), water yield in the stream (WYLD), sediment yield in the stream (SY). Finally, Figure 6 depicts the water yield in the stream (WYLD) and the sediment yield in the stream (SYLD) per sub-watershed. The above categories (WYLD and SYLD) were classified into 5 groups: very low (blue), low (green), moderate (yellow), high (orange) and very high (red).

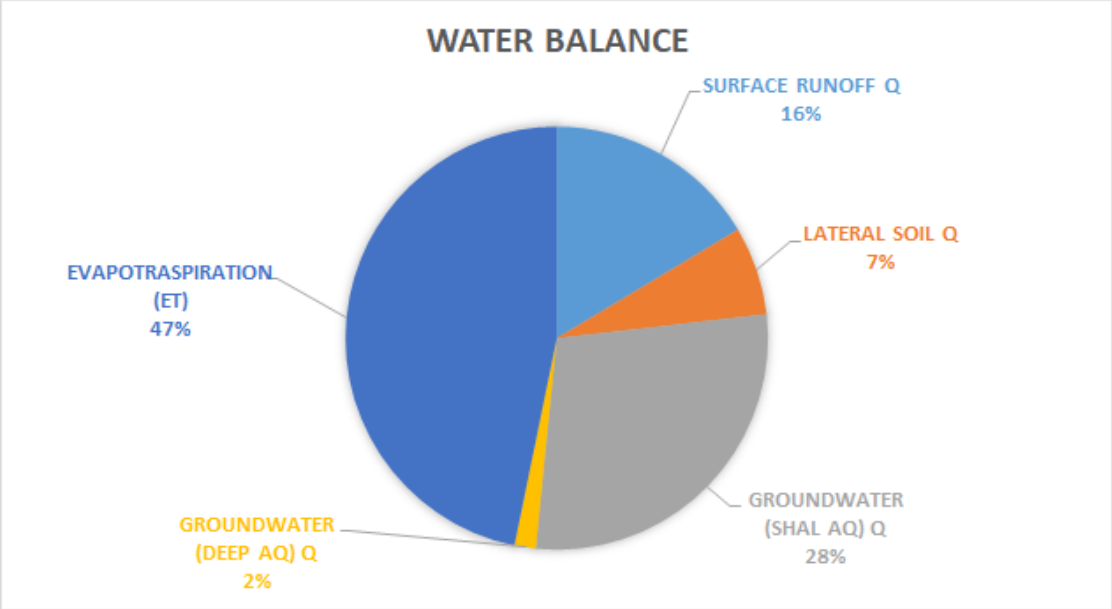


Figure 4. The simulated average water balance of the Aggitis Basin.

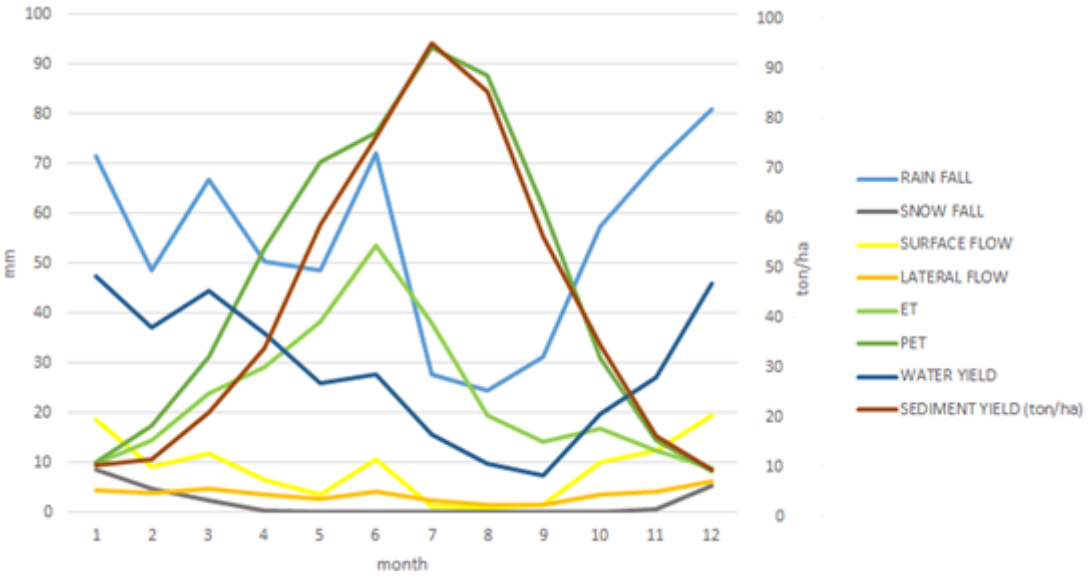
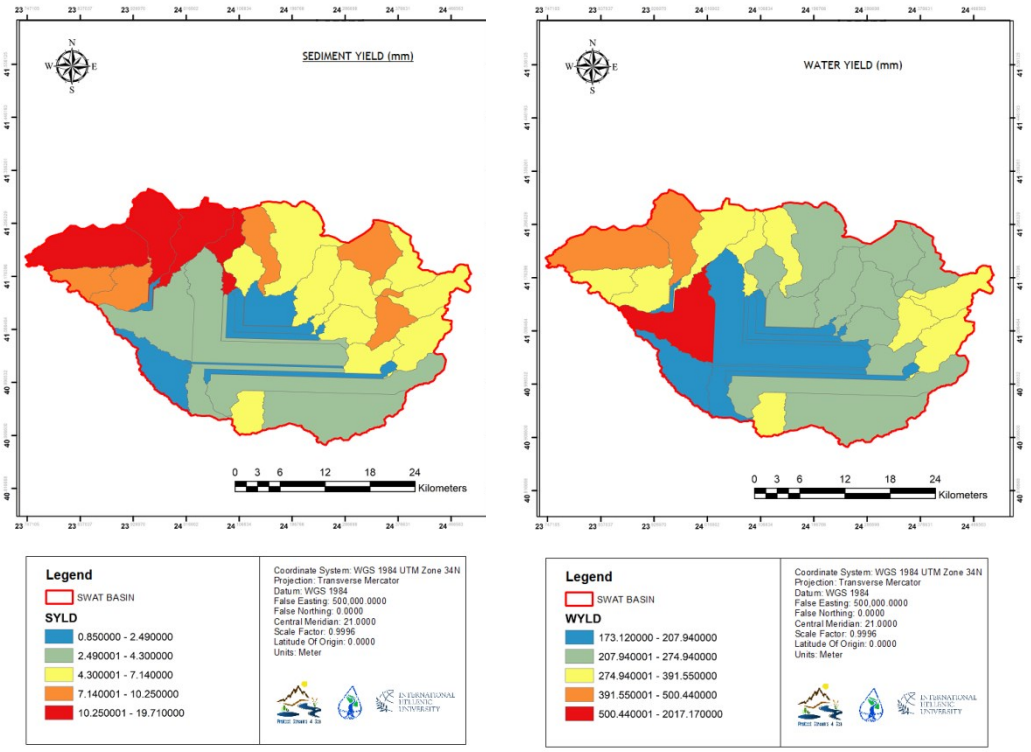


Figure 5. The simulated average monthly values of hydrologic phases of the Aggitis Basin.

A



B

Figure 6. The simulated average a) water yield and b) sediment yield per sub-watershed.

4 Conclusions

The Soil and Water Assessment Tool, commonly known as SWAT, is a physical based model as it considers many factors of the environment such as geomorphology, soils and

land-uses. It is also a semi-distributed model providing the ability to divide the area of study into different hydrological response units (HRUs) that consist of the same characteristics. It is a flexible hydrological model used for various environmental studies, worldwide and is continuously under development. The utilization of SWAT resulted to the average values of the hydrolocic phases of Aggitis Basin and the sub-watersheds where need to be monitored and managed hierarchically.

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The impacts of different land-uses on the surface runoff and erosion

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ABSTRACT

Improper land use, urbanization, and unplanned settlement, and the disruption of river dynamics (balance of stream power; driving and resistance forces) are affecting the balance between erosivity and erodibility in all terrestrial and aquatic ecosystems causing major natural disasters to occur such as landslides, overland flows and flooding. This study was aim to determine the surface runoff after rainfall events among the different land uses including lowland and highland forest, tea garden, hazelnut plantation and grassland. To accomplish this, 15 runoff plots with dimensions of 2x10m were installed to those land uses and the runoff waters were collected using 250 L water tank. As results of the work, the highest runoff volume was measured at the hazelnut plantation (15.4 L/day), followed by the grassland (6.7 L/day), tea garden (1.3 L/day), and by the both lowland and highland forests (0.9 L/day). Tea gardens had the ability to infiltrate 5 times more rain water than the grassland and 12 times more than the hazelnut garden. Compared to the forest cover, where the use of storage and water use processes between soil and plant are actively and effectively worked out, the rain water in the tea gardens is highly infiltrated and passes into percolation stage and cannot be used in the existing ecosystem, which poses a great risk for the formation of landslides particularly on the steep slopes.

Keywords: Land-uses, Surface Runoff Plot, Arhavi Watershed, Tea Garden, Landslide

1 Introduction

Soil erosion as major environmental problem causes many serious environmental problems, such as land degradation, the reduction of agricultural productivity, water shortage and pollution, and other socio-economic problems, especially in semi-arid regions. Topography, rainfall amount and intensity, soil properties and vegetation are widely recognized as the primary factors influencing runoff and soil loss rate from a watershed [1, 2 and 3]. At the hillslope scale, conditions at the soil surface vary with the topographic positions that can cause different hydrologic regimes and erosion [4]. Rainfall is one of the important factors causing soil and water loss [5]. Study of the relationship between rainfall and soil erosion is one of the important contents of soil and water conservation science, and it can provide scientific basis for the development of soil and water conservation project. Water erosion is a main reason for the soil degradation around the world. It reduces soil productivity over a long period of time, and it will eventually expose largely unproductive subsoil if it is left unchecked. Despite its sometimes destructive nature, water erosion is a natural phenomenon that can literally shape our world in large ways. There are several different types of water erosion, but they can generally be grouped into four main types. These are inter-rill/surface erosion, rill erosion, gully erosion, and streambank erosion. Change in land use would dramatically alter the hydrologic regime that may also increase the surface erosion and associated sedimentation. The objective of this study was to determine the surface runoff and sediment concentration after rainfall events among the different land uses including lowland and highland forest, tea garden, hazelnut plantation and grassland at the Arhavi River watershed, Artvin, Turkiye.

2 Materials and Methods

The study was carried out in the Arhavi basin of Artvin province. Arhavi basin has an area of 29901 hectares. Of the total area, 56% is forest (16086 ha), 27% is pasture (9135 ha) and 17% is agriculture-settlement (4426 ha). The average altitude is 1678 meters and the altitude range is from 20 meters to 3343 meters. The average slope is 53%. The average annual precipitation and temperature are 2053 mm and 14.4 C, respectively. This study used data from 15 runoff plots (3 plots for each land-use) located in the Arhavi watershed. Runoff plots are 2.5 meters wide and 10 meters long (fig. 1). The height of the metal plates is 15 centimeters, and the thickness of the plate is 3 millimeters enough to pound ground. About 7 centimeters of the plates were driven into the ground. 200-300-liter water storage tanks were placed at the exit of the runoff plots. Water samples were collected from these tanks at certain periods. The water samples taken were filtered in the laboratory using a 0.45 µm filter.

Figure 1. Runoff plot located in hazelnut garden

The surface runoff waters accumulating in the collection tanks every two weeks or after heavy rain were primarily measured and recorded as volumetric (liters). In order to determine the surface erosion, 3 sub samples of 0.25 L water were taken from the collection tanks (figure 1.). Before this samples were taken, the runoff water in the tanks was completely mixed to provide homogeneity.

3 Results

The highest runoff volume was found in the hazelnut field, followed by grassland, tea plantation, highland and lowland forests (figure 2). As for the sediment concentration in runoff, the highest value was recorded in the lowland forest, followed by hazelnut field, highland forest, tea and grassland fields (figure 2).

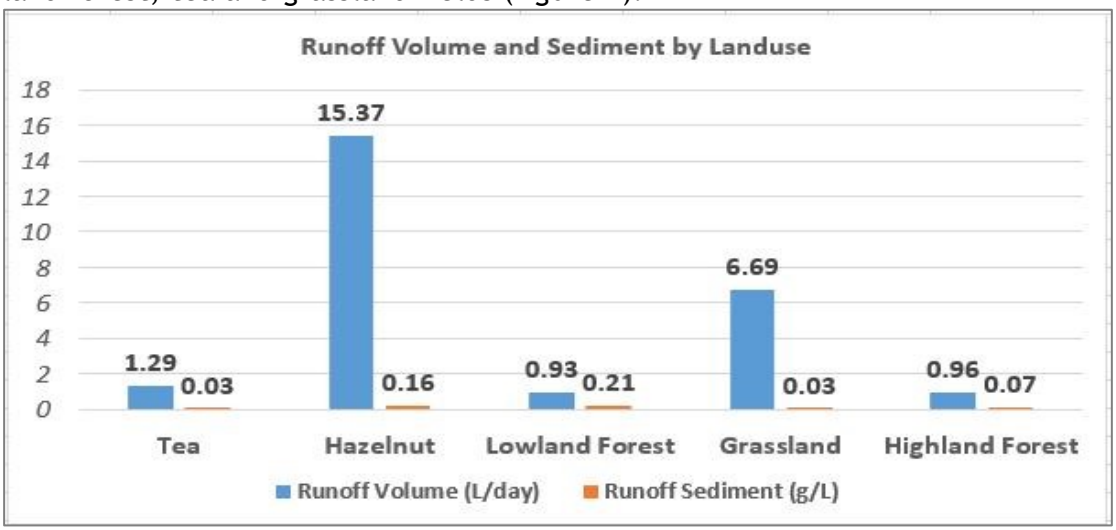

Figure 2. Mean values for runoff volume and sediment concentration among the different land uses.

The highest surface soil erosion was found in the hazelnut field, followed by lowland forests, grassland, tea plantation and highland forest (fig. 3).

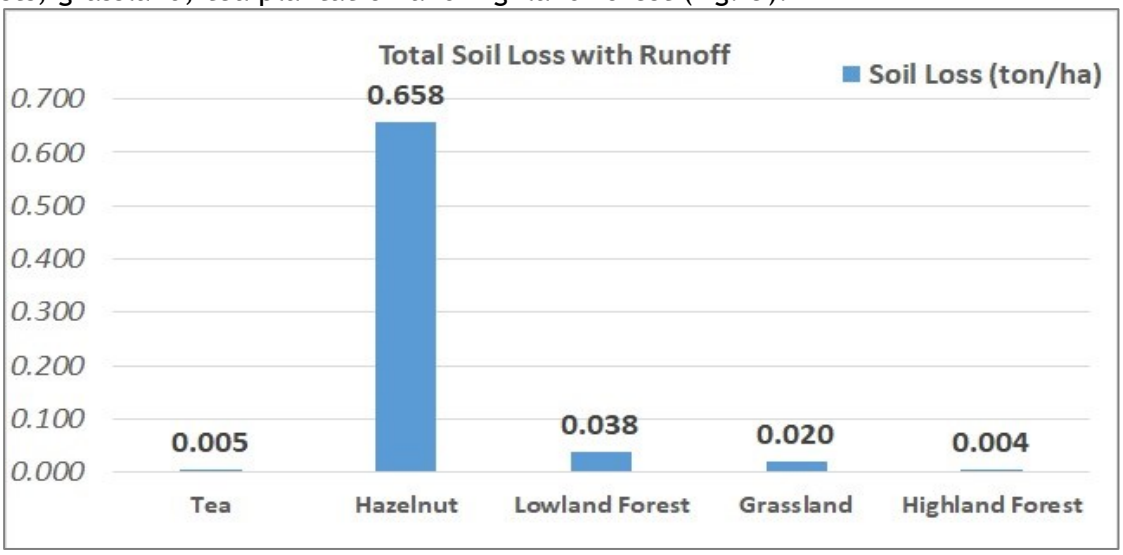

Figure 3. Surface soil erosion by different land uses.

4 Discussion

In this study, surface runoff water and soil erosion rate were tried to be estimated using total of 15 runoff plots (2.5m x 10m) established in the different land uses including hazelnut field (3), tea plantation (3), lowland forest (3), grassland (3) and highland forest (3) in Arhavi basin. Runoff plots were designed to identify the difference in land uses on the measured parameters including surface water volume and its sediment concentration/erosion. In terms of runoff water volume, the highest volume was found in the hazelnut field indicating the high risk of surface soil erosion and associated sedimentation in surface water. Along with that, the risk of flooding may also increase too. On the other hand, low rate of runoff water volume from the tea plantations on hillslope indicating increasing risk of landslide due to high rate of soil-water saturation and resulting slope failure.

5 Conclusions

As results, the highest runoff volume was found in the hazelnut field, followed by grassland, tea plantation, highland and lowland forests. As for the sediment concentration in runoff, the highest value was recorded in the lowland forest, followed by hazelnut field, highland forest, tea and grassland fields. The highest surface soil erosion was found in the hazelnut field, followed by lowland forests, grassland, tea plantation and highland forest.Land managers should pay attention to high rates of surface runoff and erosion from the hazelnut field to reduce the risk of sedimentation and flooding in downstream. Additionally, tea plantations, especially those on the steep slope, pose risk for the landslides due to their high rates of water infiltration and percolation. Tea gardens are one of the primary land use that greatly contributes to deterioration of the slope stability in the landscape and especially triggers landslides in Northeastern Turkey.

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SESSION IV “PS4S-2023”- “Protecting Black Sea Region”

Assessment of local people's perception about environmental impacts of forest land allocation: The case of projects in Istanbul

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Abstract

The allocation of forest areas for non-forestry utilization has increased in recent years thus causing increased damage to forests. These allocations and the resulting land use change have environmental impacts. In recent years, large public projects (airports, bridges, and motorways) built on forest areas in the north of Istanbul. The construction of Istanbul Airport, Yavuz Sultan Selim (YSS) Bridge, Kuzey Marmara Motorway (KMM), and connection roads in forest areas have impacts on the region's environment. Besides the impacts that occur, how these impacts are perceived by local people is of great importance. It is known that people act according to their perceptions and that these perceptions affect how they feel. In this context, the research aimed to evaluate the perception of local people about the environmental impact of the case projects built in areas allocated from forests. Questionnaires were applied to local people to collect data. Descriptive statistics and the Mann-Whitney U test were used to analyse the data. It was found that local people think that the projects have significantly reduced forest, rangeland, and agricultural areas, adversely affected water resources, changed climatic conditions, decreased the arrival of migratory birds, and that environmental problems will increase in the future. Also, the distance from the project has effects on the perception of people. It is critical to evaluate the environmental and social impacts at the planning stage of the projects that cause the allocation of forest areas and land use change.

Keywords: Land-use change, forest land allocation, environmental impact, perception, Istanbul Forests

1. Introduction

Istanbul has 240 thousand hectares (240.688 ha) of forest area, and forests constitute 44.4% of Istanbul's land surface area [1]. While the forest area per capita in Istanbul (population data 15 907 951) is 0.015 ha, this ratio is 0.27 across the country (23.110.000 ha forest and 85.279.553 population) [1,2]. When the data are analysed, it is noteworthy that the forest area per capita in Istanbul is much less than the forest area per capita in the world and the country.

Gradually increasing population, especially in a city such as Istanbul, which receives intensive migration, increases pressure on forests. According to TURKSTAT data for 2022, 15.9 million of Türkiye's 85.3 million people live in Istanbul [2]. IBB estimates that the population in 2050 will be approximately 48.5 million [3]. This rapid population growth in Istanbul brings along various problems. The resulting need for more housing and infrastructure also affects land use patterns and causes pressure on forests. Studies state that the main pressure factors on Istanbul forests are unplanned urbanisation and non-forestry permits granted from forests [4,5,6]. The studies covering the years 1971-2018 and 1980-2017 found serious decreases in forest and agricultural areas in Istanbul, while residential areas and other open areas increased at very high rates [4,6].

The pressures on Istanbul forests bring many environmental problems such as fragmentation of water production basins, loss of wildlife habitats, and damage to wildlife. It was also estimated that the airport, bridge, and highway projects in Istanbul might affect the air, soil,

and water quality, ecological balance, biological diversity, and recreational utilization of urban green areas.

Besides the impacts that occur, how these impacts are perceived is of great importance. Determining these impacts is essential to reduce or eliminate the negative impacts on the people living in this region, which has a more rural population than the centre of Istanbul, and to increase the positive impacts. Studies have shown that people act according to their perceptions and that these perceptions affect how they feel. Most importantly, even if the perceived impact is not real, it can be as harmful as a "real impact". Therefore, it is essential to measure perceived impacts. In this context, the study aims to evaluate the environmental impacts of Istanbul Airport, YSS Bridge, and KMM projects, a major part of which were constructed in the forests of Istanbul, in the context of the local people's perception.

2. Material & Method

In the research, 25 neighbourhoods close to the projects were selected as the study area, and 995 questionnaires were conducted in these neighbourhoods. In the process of developing the questionnaires, observations were made in the field, and interviews were done with local people and local headmen. In the first stage of the study, frequency distributions and medians were given within the scope of descriptive statistics for all survey questions. In the second stage, the distance to the project area was divided into two as close (1) and distant (2), and whether there is a significant difference between them was analysed by the Mann Whitney-U test.

3. Findings

According to the answers for the environmental impacts, many local residents think that forest areas (f=897) and agricultural and pasture areas (f=856) have been seriously reduced or damaged. In addition, a large number of local people state that environmental pollution has increased and natural resources have been damaged (f=783), water resources (ponds, etc.) in the region have decreased and the sources providing drinking water (especially Terkos Lake) have been negatively affected (f=732), the arrival of migratory birds to the region has decreased and their habitats have been negatively affected (f=719), and the decrease in forests has caused a change in climatic conditions in the region (decrease in precipitation, extreme temperature, excessive rainfall, etc.) (f=621). A large part of the local people thinks that noise pollution (f=757) and air pollution (f=679) have increased, landscaping of the region has not improved (f=736), the decrease in green areas in the place where they live reduces the pleasant appearance (f=770), and the green areas where they can spend their leisure time have decreased (f=937) (Table 1).

There are significant differences among the neighbourhoods in terms of distance about "forest areas (p=0.001)", "agricultural and pasture areas (p=0.000)", "water resources in the region (p=0.000)", "climatic conditions (p=0.014)", "migratory birds (p=0.000)", "air pollution (p=0.003)", "noise pollution (p=0.000)", "landscaping of the region (p=0.000)", "landscape layout of the region (p=0.000)", "pleasant appearance (p=0,007)", "recreation areas (p=0,021)" (Table 2).

When the differences are evaluated according to the distances to the projects; the participants living in the neighbourhoods close to the projects are more concerned that forest, agriculture, and pasture areas have been reduced or damaged, water resources in the region have been negatively affected, climatic conditions have changed, the arrival of migratory birds to the region has decreased and their living environment has been negatively affected, air pollution and noise have increased, pleasant appearance has reduced. In addition, these people also state that the natural landscape has not improved, and recreation areas have not increased at a higher level than those living in more distant neighbourhoods.

Table 1: Descriptive Statistics of the Environmental Impacts

Question No	Environmental Impacts Questions (n=995)	Strongly disagree (1)		Disagree (2)		Neutral (3)		Agree (4)		Strongly agree (5)		Median
		f	%	f	%	f	%	f	%	f	%	
Q1	Environmental pollution has increased, and natural resources have been damaged.	143	14.4	55	5.5	14	1.4	241	24.2	542	54.5	5
Q2	Forest areas have been severely reduced or damaged.	69	6.9	23	2.3	6	0.6	286	28.7	611	61.4	5
Q3	Agricultural and pasture areas have been reduced or damaged.	91	9.1	33	3.3	15	1.5	252	25.3	604	60.7	5
Q4	Water resources in the region have decreased, and sources providing drinking water have been adversely affected.	160	16.1	65	6.5	38	3.8	213	21.4	519	52.2	5
Q5	It caused changes in climatic conditions in the region.	219	22	78	7.8	77	7.7	166	16.7	455	45.7	4
Q6	The arrival of migratory birds to the region has decreased, and living conditions have been adversely affected.	148	14.9	62	6.2	66	6.6	201	20.2	518	52.1	5
Q7	I think that environmental problems will increase.	120	12.1	51	5.1	51	5.1	232	23.3	541	54.4	5
Q8	Air pollution has increased.	202	20.3	70	7	44	4.4	203	20.4	476	47.8	4
Q9	Noise pollution has increased.	147	14.8	68	6.8	23	2.3	235	23.6	522	52.5	5
Q10	The landscape design of the region has improved, and the image quality has increased.	517	52	219	22	38	3.8	79	7.9	142	14.3	1
Q11	The decrease in the green area where we live has reduced the pleasant appearance.	131	13.2	61	6.1	33	3.3	257	25.8	513	51.6	5
Q12	Green areas where we can spend our leisure time have increased.	662	66.5	275	27.6	9	0.9	24	2.4	25	2.5	1

Table 2: Mann Whitney U Test Results of Close (1) and Distant (2) Neighbourhoods.

Questions	Mean of Rank Values		P	n	
	1	2		1	2
Q1	510,85	483,47	0,098	528	467
Q2	522,45	470,36	0,001		
Q3	538,11	452,65	0,000		
Q4	532,61	458,87	0,000		
Q5	517,77	475,65	0,014		
Q6	535,91	455,14	0,000		
Q7	500,43	495,25	0,755		
Q8	521,88	471,00	0,003		
Q9	527,41	464,75	0,000		
Q10	476,28	522,56	0,006		
Q11	519,34	473,87	0,007		
Q12	481,66	516,47	0,021		

4. Discussion

The perception level of the local people about the environmental impact is critical in terms of analysing the dimensions and results of the impacts. The results of the case study showed that the local people's perception about the environmental impacts of forest land allocation is highly negative. The local people perceive that forests, agricultural lands, and pastures were reduced or damaged the most. Environmental pollution, damage to natural resources and wildlife habitats, decrease in water resources and migratory birds, and changes in climatic conditions were the other environmental impacts that negatively perceived issues at a high level. Besides, air and noise pollution and degradation of the green landscape in terms of pleasant appearance are perceived negatively by the local people. Moreover, the perception that environmental problems will increase is extremely high. This result proves that the people living in the region are concerned about the future of the environment where they live.

The perceptions of people who live closer to the project have a more negative perception in terms of forest areas, agricultural and pasture areas, water resources in the region, climatic conditions, migratory birds, air and noise pollution, landscaping of the region, landscape layout of the region, pleasant appearance and recreation. It can be stated that the impacts of the forest land allocations on the local people change depending on the distance. However, it should not be forgotten that those who live at a distance also have a high negative perception of environmental impact.

The ESIA reports prepared for the YSS Bridge, KMM, and Istanbul Airport stated most of the environmental impacts. However, the perception of the people about environmental damage and the impacts on their lives were ignored. The impact on society and local people has been handled within the framework of economic contribution in these reports. However, although the projects have positive economic impacts, the environmental damage will increase environmental concerns in society [7].

5. Conclusion

The results of the assessment of perceptions of local people perception about the environmental impacts of forest land allocation revealed some critical points i. the location of such projects, which cause many environmental and social problems, should be selected in a way that will not cause a large land use change, ii. the areas as far from the settlements as possible should be chosen in the construction of such projects to reduce social impact, iii. the impact of land use change and land allocations on local people should be measured for each project, and approaches to reduce and, if possible, neutralize these impacts should be taken.

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Black Sea CROSS BORDER COOPERATION

Ecologically oriented land use planning in the Lake Sevan basin

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ABSTRACT

The article discusses the methodological approaches of ecologically based land use planning. As an example, the article considered the territorial planning scheme proposed for the Sevan lake catchment area, which was implemented by us using the landscape planning methodology. With landscape planning, it is possible to develop measures and recommendations aimed at improving and protecting the water quality of Lake Sevan, as well as at the development of economic sectors justified from an ecological point of view. Priority issues are to develop concepts and instructions for ecologically oriented land use, biodiversity protection and socio-economic sustainable development of the Sevan Lake catchment, based on the existing state and international legal-normative basis. The problem of Lake Sevan, the largest freshwater reservoir in the Caucasus region, is the most important environmental and socio-economic problem of Armenia. The lake is included in the list of reservoirs of the international convention "Ramsar", as well as in the UNESCO list as a specially protected reservoir. The degradation of the lake is fraught with a significant change in the regime of surface and groundwater and general aridization of the region, the loss of a promising source of drinking water supply, an important recreational facility, as well as a base for significant biological diversity, in particular for migratory birds and unique endemic flora and fauna.

Keywords: territorial planning, landscape planning, territorial development, environmental management, protection area, water resources.

1. Introduction

Today, one of the central directions of regional development is the task of combining the political goal of equalizing the standard of living in advanced and depressed (or lagging behind) regions with the requirement to reduce the burden on natural resources and the environment. Approaches to solving this problem, obviously, cannot be universal, but the common path is seen in a change in ideas about a single development model for all regions and countries through classical urbanization and industrialization. Landscape planning can also play a significant role in the search for regionally specific and ecologically meaningful development scenarios. By ratifying the European Landscape Agreement in 2004, Armenia undertook the obligation to implement the conservation, management and planning process of natural and anthropogenic landscapes. In the context of the implementation of the latter, the RA Government in 2012 developed a landscape conservation, management and planning strategy in Armenia.

2. Methods

The landscape planning methodology was used to present proposals for ecologically justified land use of the Sevan Lake catchment basin. The main approach to landscape planning is the analysis, assessment and mapping of inventory data according to significance and sensitivity, from which the use of the area is developed through comparison. The order of achievement of the written goals. Mathematical modeling and cartographic methods are

widely used in landscape planning tools. The goal of landscape planning is the definition of ecologically oriented land use preconditions, which takes into account the combination and ordering of the development priorities of the area. The necessary directions for the development of different types of earth systems and their condition are determined through the measures. The main goal of such an approach is to develop a plan for the sustainable development of the area, which is possible if two interrelated problems are solved simultaneously:

- by regulation of land use of the area,
- by developing the concept of socio-economic development.

3. Results

Ecologically oriented land use planning of Lake Sevan basin was carried out in the following sequence of actions:

1. Inventory _ collection, processing and mapping of data on natural and anthropogenic landscapes.
2. Assessment _ data analysis, evaluation and mapping of natural and anthropogenic landscapes using existing criteria and developed scales for their significance and sensitivity.
3. Development of sectoral objectives and integrated concept of territorial development _ Zoning and mapping of territories according to the importance and sensitivity of individual natural components for the implementation of the functions of sectoral goals. Development of the concept of territorial development.
4. Development of main lines of action and priority measures _ Proposing the main types of action measures based on the objectives of land use and development and the proposed ratio of measures of the types of objectives. Based on the integrated map of objectives, zoning of territories according to types of actions and measures.

4. Discussion

Based on the natural features of the studied Sevan Lake basin, conservation importance, inventory and assessment results, sectoral development goals and integrated concept, the main directions of land use actions and measures were proposed (Figure 1).

The zoning of the Lake Sevan basin according to the types of actions and measures was carried out on the basis of the generalized map of goals. The following types of goals and activities are intended for the planned area:

- General measures for the entire area, aimed at the implementation of its development concept.
- Measures aimed at maintaining the existing condition or use of individual sites of the planned area.
- Activities aimed at developing existing or intended uses.
- Measures to improve performance for conservation purposes.
- Measures aimed at improving performance for development purposes.
- Key actions for the improvement of the social sphere.

In accordance with the development concept of the area, descriptions of specific activities are combined with general action directions for the entire area. The description of individual types of activities was done by maintaining similar levels of scaling and detailed elaboration of measures corresponding to the sectoral structure of the economy and land use.

ACTIVITIES AND MEASURES

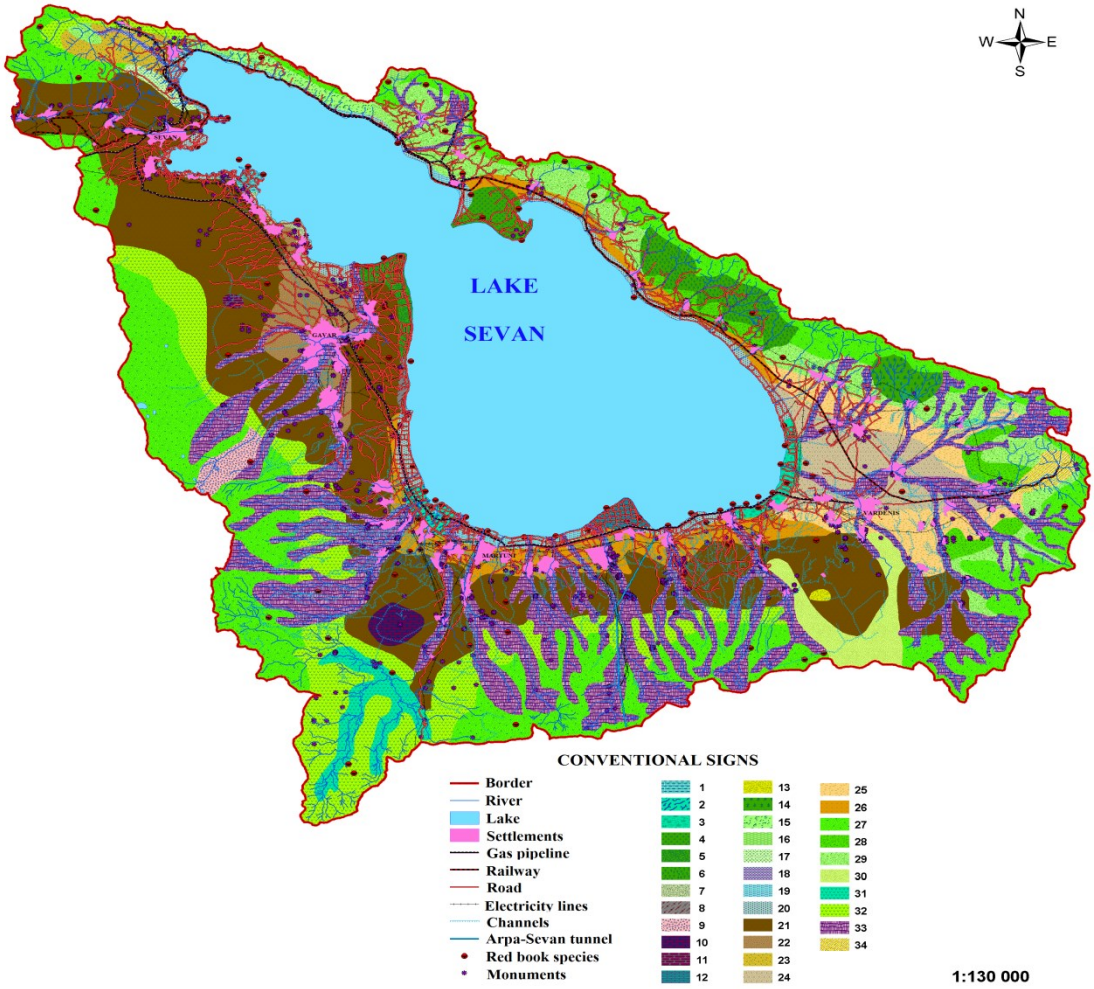

Figure 1: Main directions of activities and measures

Table 1. Legend to Figure 1 (map of actions and measures)

Economic function of the territory	Actions and measures
Conservation	
Mostly within the limits of the «Sevan» National Park	
Reserves 1. Norashen – ornithological. 2. Lichk-Argichi - a nesting place for ducks, large outcrops mineral waters, picturesque forms of river valleys. 3. Gili - biogeochemical barrier-nesting place for waterfowl. 4. Artanish - sparse forests on sedimentary rocks.	Restriction of all kind of economical activities, that violating the regime of the reserve
Sanctuaries 5. Gavarageti - forest plantations. 6. Sparse juniper-oak forest on ophiolite rocks and oak forest	Restriction of all kind of economic activitie that violating the regime of the sanctuarie
Red Book species	Strict guard
In the area of direct impact	
7. Lchashen lunar landscape-chingily on young lava flows w shrub vegetation. 8. Artsvakar tectonic reverse fault. 9. Gridzor trough valley with mineral water outle hydrothermally altered rocks and rare cholcophi vegetation. 10. Armagan-volcanic cone with a crater lake. 11. Blur is a young volcanic cone with a crater. 12. Tsovinar-biogeocenotic station of the RA Academy Sciences. 13. Gegakar is a rare tract of shrub cenoses within lava massi 14. Tigranaberd-dwarf creeping juniper. 15. Areguni-oak thickets of residual genesis. 16. Drakhtik-alpine meadows with rare flora. 17. Mashtotsner – remnants of forest vegetation. 18. Dzknaget obsequent valley.	Prohibition of all types of economic activit that violate the regime of reserves and natural monuments.
Social	
Infrastructure. Historical and natural monuments.	• Infrastructure improvement. • Care and creation of appropria infrastructure.
19. Recreation, rest and economic activity within the NP Sevan. 20. Tourism and sports with Sevan NP and zone of direct impact	• Arrangement of places of recreation a rest. • Cognitive and aesthetic. • Development of infrastructure for wint sports.
Development	
Agricultural zone	
21. Sowing grain crops and perennial grass. 22. Sowing grain crops and vegetable. 23. Sowing of perennial grasses and cereals. 24. Sowing grain crops and technical cultures. 25. Sowing of cereals and perennial grass. 26. Sowing of vegetables and establishment of fruit orchards	• Improving the use of agricultural and ru lands through the limited use of orga fertilizers and efficient irrigation. • Efficient irrigation without the use fertilizers. • Efficient sprinkler irrigation.

	• Efficient sprinkler irrigation without the u of fertilizers and chemical protecti measures.
Livestock zone	
27. Summer pastures of intensive use. 28. Spring pastures. 29. Autumn-spring pastures, hayfields in some places. 30. Autumn pastures. 31. Hayfields, drained in places. 32. Hayfields, getting natural fodder for hay.	• Irrigation and regulated use. • Regulated use using phytomelioration a fertilizers. • Regulated use with the application of an erosion and anti-mudflow measures. • The use of phytomelioration and t collection of stones. • Extensive development, limited he grazing. • Restriction of herd pasture.
Sanitation	
33. River valleys. The water area of Lake Sevan, coastal par especially the mouths of the rivers flowing into the lake. 34. Mining industry.	• Prohibition of construction, emissio pollution and active forms of use of natu resources. • Prohibition of construction, emissions a pollution. • Ecologically justified exploitation of spring

5. Conclusions

Thus, the study carried out within the framework of the article allows us to claim that landscape planning can be used as a methodology for ecologically oriented land use planning of the Lake Sevan basin. The work done with the landscape planning tool makes it possible to show in general terms the steps and actions that should be taken to maintain the purity of the lake water, as well as to support the organization of the economy without causing any damage to valuable biotopes and the environment.

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Optimizing wastewater treatment and agriculture sustainability: Investigating the use of primary and activated sludge combination and flotation for resource recovery

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ABSTRACT

This paper investigates technological issues related to wastewater treatment and agriculture sustainability. The study explores the use of a combination of primary sewage sludge with activated sludge to mitigate the impact of organic substances on the wastewater treatment process. Additionally, the rationalization of using organic sludge isolated from wastewater to reduce the cost of organic processing in pretreatment and obtain an environmentally friendly product through flotation for agricultural use has been examined. The developed process of concentrating residual organic solids expands the industrial possibilities of utilizing activated sludge in optimizing purification processes and obtaining valuable products. The findings of this study have implications for improving wastewater treatment efficiency and promoting sustainable practices in agriculture.

Keywords: Activated sludge, Aerobic-anaerobic meso-thermophilic separation, Soluble nitrogen forms, Wastewater

1 Introduction

Being one of the great modernizations in the field of environmental engineering in the twentieth century, the activated sludge process plays an important role in contemporary wastewater treatment [1]. As a result, activated sludge, is unavoidably of the secondary stage of wastewater treatment produced in large amounts. Sewage sludge in urban wastewater treatment plant (WWTP) contains a large amount of water, perishability and strong unpleasant odor. If sludge accumulates arbitrarily unprocessed, it is able to cause groundwater and soil pollution due to erosion and rainwater overflow, which may endanger human health. Therefore, the high production of sludge determined that the treatment of the sludge would be a significant proportion of secondary pollution control of the WWTP [2]. As a result, the reduction of sludge has become a key issue for the operators of municipal WWTP [3,4]. Sludge contains many organic substances, including proteins, polysaccharides, nucleic acids and humic acids, as well as various inorganic minerals such as quartz, alumina, iron oxide, phosphate, calcium and magnesium. Meanwhile, sludge features may be influenced by factors such as wastewater treatment technology, seasonal temperature changes and regional water use habits, which can cause significant changes in the sludge chemical composition. On the other hand, activated sludge volume comprises about 1 %-2 % of the volume of sewage flowing in the plants, concomitantly containing around 50 %-80 % of waste stream pollutants. Final treatment and disposal of activated sludge are associated with very high capital and operating costs, up to 60 % of total treatment costs [5-7]. Activated sludge has been shown to be effective in pretreatment for reducing organic load

in meat and fish processing waters. Thus, the soluble part of the organic matter in the wastewater of these combined plants is reduced, but also the organic solids are compacted.

2 Materials and Methods

Laboratory glassware and purity reagents according to the requirements of ISO methods [8-18] were used. For the estimation of the organic matter content, the chemical oxygen consumption (COD_{Cr}) and the biochemical oxygen consumption (BOD_5) were determined, and for the elucidation of the presence of functional groups and of the buffer properties, the alkalinity was determined. The content of stable and soluble forms of nitrogen, NH_4^+, NO_2^- and NO_3^-, was also determined.

3 Results

A difficult problem is associated to the fact that the sediments of biological treatment installations which contain mainly activated sludge, is the treatment and use of sludge, especially primary sedimentation tanks, as well as an excess of activated sludge formed in aeration tanks is 0.5-1.2 % of the volume of treated wastewater. The cost of processing sludge from wastewater, taking into account energy consumption and employees' salaries is up to 50 % of the operating costs of the entire treatment process and is depending on the chemical composition of the wastewater. Treatment of sludge by aerobic-anaerobic meso-thermophilic separation (AAMS) produces:

- decrease in the volume of stored sludge;
- economy of flocculants;
- reduction of the organic component of the wastewater received in the primary container when treated with water extracted from activated sludge with better quality indices.

As it is known, depending on the ability to adapt to thermal conditions, microorganisms are classified into: cryophilic ($t \leq 28\ ^\circ C$), mesophilic ($t = 28 \ldots 42\ ^\circ C$) and thermophilic ($t = 45 \ldots 55\ ^\circ C$) [19-21]. Within the limits of the thermal values necessary for the development of microorganisms, there is a narrow interval of temperatures between 38 °C and 43 °C, called thermo-mesophilic interval, tolerated by both meso- and thermophilic microorganisms. The study of the processes that take place at the combination of two types of organic residues, coming from biological treatment plants: the primary sediment, resulting from the separation of organic matter from wastewater with activated sludge, combined with raw sludge, taken from the primary decanter and which supports the anaerobic thermophilic process and the active, well-aerated sludge residue, which has an aerobic activity regime. The meso-thermophilic process involves increasing the temperature to the maximum value, tolerated by the mesophilic sphere, through which this process of activity is maximum. Instead, the thermophilic - enzymatic process, supported by the bacterial sphere, which is active in the corresponding temperature interval, will be partially minimized. Thus, the thermophilic decomposition of compounds of protein origin will decrease in relation to the consumption of soluble compounds, consumed by microorganisms with mesophilic activity.

As a result, the ratio of suspended and soluble compounds, most of which being volatile, short-chain organic acids, and ammonia will increase. The combination of these two components (primary sediment and activated sludge) leads to the reduction of the stability of the organic colloids with a coagulation effect of the suspending particles in the dispersed system. A floating effect occurs. Table 1 reflects the results of the combination of the primary wastewater sediment (raw sediment) with the activated sludge in different proportions and in thermo-mesophilic conditions.

Table 1. Concentration of the organic part from the mixtures with raw sediment and activated sludge

No	Composition of mixtur from raw sediment: activated sludge, % : %	Initial COD_{Cr}, mg/L	Final COD_{Cr}, mg/L	Concentration coefficient	Separate water turbidity, conventional un	NH_4^+, mg/L
1	15:85	7466	26162	3,504	0.162	19
2	20:80	9302.5	36973	3.975	0.210	25.1
3	30:70	12730	38353	3.013	0.303	23.6
4	40:60	16158	39440	2.441	0.360	26.6
5	50:50	19584	40167	2.051	0.398	27.0
6	60:40	22032	41971	1.905	0.407	28.3
7	0:100	2448				
8	100:0	36720				81.0

4 Discussion

There are interactions between species of microorganisms, which lead to the establishment of an optimal equilibrium for the wastewater treatment process under certain conditions. The developed solution consists in maximum using of the specific features of the transformation processes conditioned by the activity of microorganisms in meso-thermophilic conditions, at vital temperatures for mesophilic and thermophilic species. Usually, fermentation is an exothermic process, but for the initiation of the meso-thermophilic process it is necessary to preheat the residual solids. For this purpose, any accessible energy source can be used: electric plunger, solar radiation, biogas obtained on the spot, etc. At the same time, a good thermal isolation is required. Taking into account the fact that the number of sunny days in the Republic of Moldova is about 280-300 per year and using adequate devices to capture solar energy in the wastewater treatment process, a substantial energy saving is obtained. In addition to maintaining optimal meso-thermophilic conditions, it is also important to combine two processes, which complement each other. The first process is anaerobic, rich in soluble nutrients, containing species of anaerobic microorganisms, and the second process is aerobic and contains predominantly aerobic microorganisms with an insufficiency of nutrients. Altogether, as shown above, the process achieved by combining aerobic and anaerobic processes is more efficient than each of them realized separately.

5 Conclusions

The combination of primary sediment with activated sludge in proportions close to technological ratios results in a significant concentration of three-four times within one hour of flotation. The utilization of aerobic-anaerobic meso-thermophilic separation for separating and concentrating the organic part from solid residues expands the technological possibilities for using activated sludge in optimizing purification processes and producing a fertilizer product for agricultural use. Furthermore, compaction of the separated organic sediment reduces the volume of anaerobic fermenters and containers required, as well as lowers energy consumption.

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

Optimizing nitrogen and phosphorus recovery via anaerobic digestion supernatant and struvite production: A path to optimal resource recycling

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ABSTRACT

This research primarily aims to identify potential partners for the for the current *Interreg NEXT Black Sea Basin Programme*, with a specific focus on the objective of "Enhancing the protection and preservation of nature". The purpose of this research is to provide a brief overview of the proposed approaches to mitigate the risk of nitrogen (N) and phosphorus (P) supply shortages, prevent potential resource depletion, and reduce environmental pollution. The paper outlines the key methodologies for the planned activities, along with the anticipated economic, commercial, social, and environmental impacts resulting from their implementation.

Keywords: Anaerobic digestion, Nutrients, Pollutant, Sludge, Struvite, Wastewater treatment plant

1 Introduction

The global economic progress has resulted in excessive utilization of nitrogen (N) and phosphorus (P) inputs in various industrial and agricultural processes. However, unlike the carbon cycle, the biochemical cycles of N and P are distinct and are recognized as critical boundaries for the planet. Nitrogen and phosphorus are essential for food production as plant nutrients, but they cannot be produced synthetically or replaced by other substances. Nonetheless, the inefficient use of N and P has severe repercussions on ecosystems. The current European limits for N and P losses are exceeded due to variations in soil and agricultural practices, and there are significant regional differences in the occurrence of these losses. At a global scale, the overloading of Nitrogen and Phosphorus beyond safe planetary boundaries has become a critical systemic challenge with far-reaching implications for life on Earth [1-4]. The accumulation of excessive nutrients in the air, water, and soil has significant impacts on public health, climate, and the environment. Despite the successful removal of pollutants and pathogens, many wastewater treatment plants (WWTPs) continue to discharge substantial quantities of valuable nutrients, including human excreta, into the environment, including rivers, estuaries, seas, dewatered sludge, and the atmosphere. The chief objectives of the planned activities are centered around the recycling of nitrogen (N) and phosphorus (P) from secondary resources, specifically anaerobic digester supernatant.

This approach aims to develop nutrient cycles while conserving limited primary N and P resources. The project will also include an analysis of environmental contaminants present in struvite, a byproduct of the N and P recovery process. The main objectives of the proposed activities are as follows: (a) Production of high-quality struvite to prevent nutrient-related pollution that can damage water quality; (b) Contribution to a circular economy by

recovering and processing nutrients from wastewater treatment plants (WWTPs); (c) Reduction of the ecological and climate footprint associated with the struvite process; (d) Investigation of the presence of drug residues, organic pollutants, pathogens, and heavy metals in the recovered struvite; (e) Cost reduction for struvite crystallization through the use of magnesium waste (e.g., refractory brick) as a source of magnesium.

2 Methods

In wastewaters and soil heterogeneous aqueous (WSHA) systems, the nutrients, heavy metals, P and N-containing components exist in different forms depending on the concentrations of various other species, organic matter, the types of minerals and the pH value. The derived earlier thermodynamic expressions of complex equilibria for the conditions under which solids involving common ions can coexist at equilibrium, the acid-base and mineral equilibria and complex formation will be applied. The theoretical part of this work will utilize relationships coupled with original mass balance constraints, where the solid phases are explicitly expressed. The ammonium, phosphate, nitrate, nitrite, sulphide, silicate, fluoride and sulphate acid-base systems will be included in the derivation, as well as the contribution of other minor acid-base species and organic acids, which can substantially contribute to soil solutions resistance. The formation and stability of major chemical species (MCS) of these components, which controlled their content, will be considered in derived original mass balance and thermodynamic equations [5-12]. The main approaches for estimating individual concentrations of MCS will involve the use of reliable thermodynamic data, together with experimental measurements of free or total concentrations of major components. The effect of major factors influencing on the distribution and concentration of soluble and insoluble species of MCS in WSHA systems will be analyzed. The new type of diagrams, which quantitatively describe the distribution of soluble and insoluble, inorganic and organic, monomeric and polymeric MCS species in heterogeneous systems in a large range of pH values will be carried out [6,8,10]. In order to achieve the project aims, the first time there will be thermodynamically analyzed, on the basis of the developed and applied quantitative theory of buffer action in two-phase systems, the buffer capacities of heterogeneous processes of formation of the phosphate of Ca^{2+}, Mg^{2+} and heavy metals (HM) towards pH, pMg and pCa, where pMg(Ca) = -log[Ca^{2+}] (or -log[Mg2+]). The deduced general expressions will be verified by experimental data obtained within the expected project and applied to wastewaters and soil solutions and possible changes therein. The notion of a generalized process equation will be used to describe the process of precipitation-dissolution of P and N containing minerals in the presence of different components of analyzed supernatant and soil solutions. The global variation of the Gibbs energy will be deduced and computed from the derived generalized equation. The optimum composition of the reaction mixture for technological schemes and soil solution compositions will be determined. The main tools and methods to be applied during the project are: (I) chemical thermodynamics, (II) complex chemical equilibria in heterogeneous systems, (III) differential equations, (IV) writing and adapting computer programmes to calculate systems of non-linear equations and deduced formula. The developed thermodynamic approach will be applied and developed for complex chemical equilibria in heterogeneous systems containing two or more solid phases. This approach will utilize thermodynamic relationships joined with original mass balance constraints, where all the soluble and insoluble components in wastewater and soil solutions will be explicitly expressed. Computing of global change in Gibbs energy equations deduced will be applied for a set of chemical equilibrium equations in multi-species and multiphase wastewater and soil solution systems. The criterion of the intensity of buffer action theory [5,7,11] will be developed and applied for the investigated systems. Additionally, the determination of buffer capacity towards the soil main components will be performed using equations, deduced within this project. The use of the buffer approach will yield our extended knowledge and a deeper understanding the dominant processes that control the

concentrations of components as well as a powerful tool for assessment and prediction of long-term resistance of contaminated soil systems. It is expected that applying the methodology outlined above, the buffer capacity approach will provide a suitable method to estimate whether or not the pollutant (especially heavy metals) content will change appreciable under external influences (perturbations). The new type of diagrams, based on thermodynamic, graphical and computerized methods, which quantitatively describe the distribution of various soluble and insoluble species in ocean systems in a large range of pH values, for different C, P and T, will be used. Deduced equations for mass balance equations within this project, where solid phases are explicitly expressed, will easily be computed to avoid time consuming numerical iterative calculations.

3 Results

A thermodynamic model of the process is crucial for conducting assessments and forecasts on the evolution of natural systems over time. The proposed project aims to address critical knowledge gaps and technical requirements in nutrient management by offering a systematic solution for struvite recovery. To achieve this objective, the project team will provide solutions such as sustainable supply-chain management, enhanced resource efficiency, waste valorization, and circular economy assessments. The anticipated outcomes of this research will yield valuable information on mechanisms for maximizing nitrogen and phosphorus recovery through struvite production. Identification of optimal parameters for the struvite crystallization process will minimize downtime and offer cost-effective recovery options, making it an attractive choice for next-generation wastewater treatment plants. Overall, the projected activities will make significant contributions to integrated nutrient management efforts and further the ambition of establishing a circular economy. The target of this collaborative project is to mitigate the risks associated with nitrogen (N) and phosphorus (P) supply, prevent resource depletion, and reduce environmental pollution. The proposal project aims to directly contribute to the economy by enhancing the efficiency of N and P recovery, which is currently wasted as pollution. Furthermore, the intended activities will provide valuable information on the application of N and P recovery techniques in wastewater treatment facilities, and the findings and outputs may inform future investment cycles. This project proposal aims as well to establish a foundation of knowledge and tools for addressing the problem of nitrogen and phosphorus (N/P) pollution, including a better understanding of their behavior and characterization. The planned activities will involve comprehensive research on optimizing complex chemical equilibria, chemical speciation, and buffer action, in order to gain insights into the parameters that control struvite formation. The research will also generate critical information on pollutants, including organic and inorganic substances, through careful environmental analyses that target urgent knowledge gaps identified by local authorities. The results of the planned research will provide key inputs for risk prevention and mitigation solutions, supporting policy development, regulatory action, and risk communication efforts. The project contributions may also extend to other environmental and social impacts, such as the Zero Pollution Action Plan on persistent and mobile chemicals, the Circular Economy Action Plan to minimize the presence of harmful substances in human and environmental health, and increased social awareness of persistent and mobile chemicals.

4 Conclusions

The paper presents a brief overview of projected activities to address the risk of nitrogen (N) and phosphorus (P) supply shortages, mitigate potential resource depletion, and reduce environmental pollution. The key methodologies planned for implementation, along with their expected economic, commercial, social, and environmental impacts are drawn. The formulated purposes to promote recycling of nitrogen (N) and phosphorus (P) from anaerobic digester supernatant are as follows:

(I) Production of high-quality struvite to prevent nutrient-related pollution and potential water quality damage.
(II) Contribution to a circular economy by recovering and processing nutrients from wastewater treatment plants (WWTPs).
(III) Reduction of the ecological and climate footprint associated with the struvite process.
(IV) Acquisition of information regarding the presence of drug residues, organic pollutants, pathogens, and heavy metals in the recovered struvite.
(V) Cost reduction for struvite crystallization by utilizing magnesium waste (e.g., refractory brick) as a source of magnesium, thereby reducing raw material costs.

Acknowledgments: This work was carried out within the Moldovan State Program (2020-2023) "Study and management of pollution sources to develop recommendations for implementing measures to mitigate the negative impact on environment and human health", project number: 20.80009.7007.20.

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SESSION V “PS4S-2023”- “Water Management”

Project funded by EUROPEAN UNION

Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

The WaSec Project - Sustainable Water Management in the Eastern Mediterranean through New Courses with Innovative Topics and Learning Approaches

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ABSTRACT

Climate change is substantially affecting the Eastern Mediterranean region that is already facing serious water scarcity issues. The need for professionals in the water sector with a science-based background but also knowledge-able with innovative and applicable management methods and tools adapted to the region is very evident. Emphasis was given on developing a master's program form Palestine and Jordan, although the new master could easily be utilized to train professionals from the neighboring countries. Water management can be a complicated issue because of the many interested stake-holders. This is why the new courses provide a holistic approach considering all views before finalizing the optimum solutions. In addition, the courses train in new technologies, methods and approaches and how they can be incorporated in water resources management plans. The end result was eight new courses. These courses can be taught in a blended matter because they are placed on a virtual learning platform. The development of the portal is an innovation for the region and allows distance learning for education in rural areas. Overall, the future professionals that graduate from this program will have the skillset to promote and enhance sustainable water management in region and be attractive to the private and public water sector.

Keywords: Water Management, Education, Climate Change, New and Innovative Courses, Virtual Learning Platform, Eastern Mediterranean.

1 Introduction

Climate change is and will continue to impact the water resources of the Mediterranean [1, 2]. Studies show an increase in mean and extreme temperatures as well as changing precipitation patterns [3, 4]. The overall amount of precipitation is expected to decrease while the intensity of events will increase. The alteration of the precipitation pattern and the increased evapotranspiration combined with other anthropogenic stresses, reduce surface and ground water availability [5, 6]. These changes that are happening and will continue to escalate, indicate that measures need to be taken in order to continue to have water availability in the future for the Eastern Mediterranean region [7, 8]. The first step is to educate and train professionals to know how to conserve and eliminate the waste of water while considering potential climate change impacts [9-11]. These professionals should be able to develop water resources management plans based new and innovative approaches, tools and methods.

Through this project a new master's program was developed with courses that provide state-of-art science, practical applications and tools while collaborating with organizations and enterprise of the water sector. This should lead to future water professionals with the necessary scientific background and knowledge of new and applicable methods and tools adapted to the region.

2 Study Region

The focus was on the Eastern Mediterranean, a region facing serious water scarcity issues. This region includes Cyprus, Greece, Lebanon, Syria, Israel, Palestine, Turkey, Egypt, Libya and Jordan. The climate is typical Mediterranean, with limited to no rain during the summer, and most of the rain during the winter. Overall, the climate is dry, and climate change is only exacerbating these dry conditions. Emphasis was given on developing courses to meet the needs of the water sector of Jordan and Palestine. Still these results can be applied to neigh-boring countries such as Lebanon, Syria, Israel and Egypt.

3 Teaching Approaches

This new master's program developed innovative and practical courses. These courses provide an improved understanding on water resources processes and how to develop sustainable management plans. In addition, they teach new technologies and methods to students that can incorporate them in water resources management plans. Water, offers many services to many different sectors that can lead to conflict among the stakeholders, making water management a very difficult task. The new courses provide a holistic prospective on water issues that will enable them to find the optimum solutions based on the specified objectives by taking into consideration all interested parties. Major emphasis in these courses will be given in understanding the principles of water resource management along with water conservation and recycling techniques. In addition, the impending climate change impacts will put more pressure on water resources. Understanding and incorporating the potential impacts in management will be a focal point of the program (understanding climate change forecasts and learning climate modeling).

Overall, the purpose of the project is to develop courses for Eastern Mediterranean countries. Another key aspect was heavily involving the people that hire water managers in developing the courses to provide the necessary tools that water professionals require to be attractive to future employers. Finally, the involvement of many different countries, also promoted the internalization of the master's program.

4 Educational Material

4.1 Innovative Courses

Eight courses (Table 1) were developed with feedback by the private and public water sector of Jordan and Palestine through seven neighborhood network meeting, conducted in person and online, and five tester workshops conducted in per-son. These courses are for the Master's level and each course has 13 lectures. The teaching style is blended (online and in person). The courses will be taught in Palestinian universities (Al-Quds University and Palestine Technical University – Kadoorie) but there will be guest lecturers from the other partners. A brief description of each course is provided below.

Water Energy Food Nexus: The course introduces students to the fundamental concepts of the nexus approach and presents an analysis for food production and distribution, water and energy management, focusing in arid and semi-arid areas. Climate Change & Water Sustainability: The students become familiar with climate change projections and relevant data generation used to design local and global policy and management plans related to climate change mitigation and adaptation. Water Policy & Governance - Transboundary Basin: This course aims to high-light the interaction between hydrological and socio-economic factors in a trans-boundary river basin.

Hydrology and Hydrogeology: Study of the water cycle, with special attention to semi-arid regions. Numerical equations and statistical methods will be present for the calculation of precipitation, surface and near subsurface runoff, and infiltration.Water and Wastewater Treatment & Reuse: The course aims to introduce the students to the various methods and processes used in the treatment of water and wastewater. Entrepreneurship and Innovation in Water: Students are trained on the: value chain of organizations related to water; design of appropriate management strategies for the company; elaboration and management of business plans and studies of profitability of investments in water; and market research processes related with water.

Water Quality: The course teaches water quality physical, chemical and bio-logical dimensions. It also showcases the uses of environmental isotopes applications in water quality along other monitoring and assessment tools.

Integrated Water Resources Management: The course teaches the basic principles while providing examples of integrated water resources management, eco-hydrological and ecosystem-based approaches and nature-based solutions.

Table 1. The eight courses of the MSc program

Course Topic
1. Water Energy Food Nexus
2. Climate Change & Water Sustainability
3. Water Policy & Governance - Transboundary Basin
4. Hydrology and Hydrogeology
5. Water and Wastewater Treatment & Reuse
6. Entrepreneurship and Innovation in Water
7. Water Quality
8. Integrated Water Resources Management

4.2 Virtual Learning Platform

The new courses and other related material are available through a Virtual Learning Portal (see https://vlp.wasec.net/) (Figure 1). The development of the portal is an innovation for the region and allows distance learning that could be very important for the education of students from rural areas. It contains all of the information regarding the new courses and is the main repository of the learning materials (Figure 2). It can be used simultaneously by at least 100 users and can allocate different types of roles (lecturers, students, visitors). It also includes e-mailing abilities, discussion groups and offers the possibility of being

tailored to each courses needs and particularities. The Virtual Learning Portal is in Arabic and English.

Its main functions of the learning portal are to: a) provide a distance learning tool that contains learning materials, methodologies and assessments, b) provide an e-learning and teaching environment that corresponds with 21st century educational approaches and needs, c) provide a multifunctional repository containing multiple educational water-domains consisting of modules and intended learning outcomes, allowing each partner to design as needed courses or training materials, d) create teaching communities and provide them with discussion forums. Overall, this is an innovation in the region that enhances education in water resources management and promotes water sustainability and security and climate change adaptation in the region.

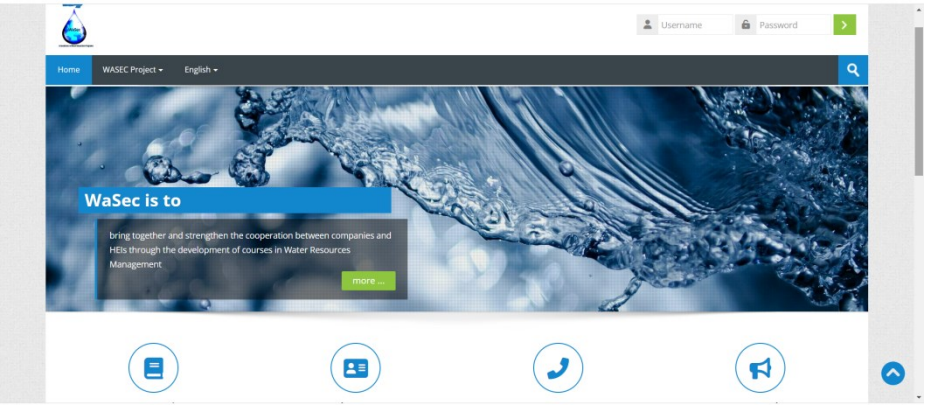

Figure 1. The main interface of the VLP.

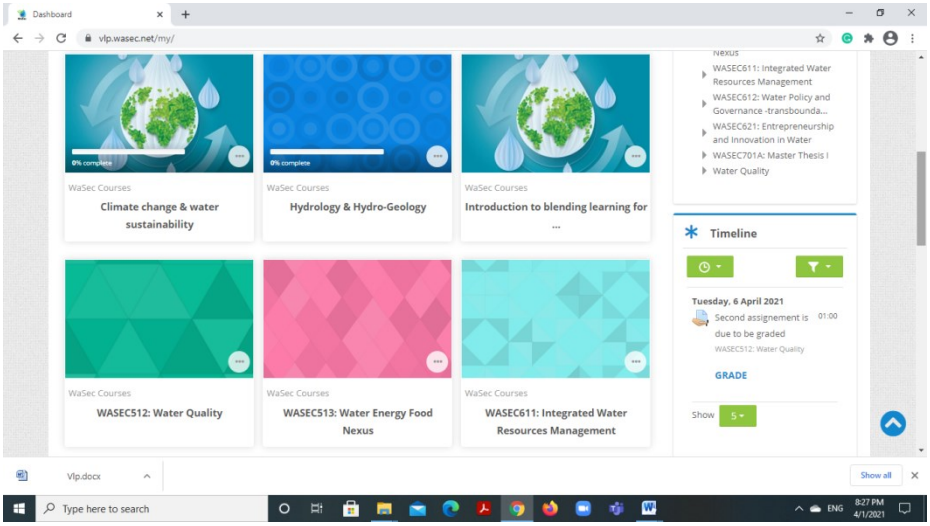

Figure 2. The different courses included in the VLP.

5 Conclusions

An innovative modern in material and topics master program but also with new learning approaches was developed. The program's courses are state-of-the-art and provide a holistic view on sustainable water management specialized for the region. The private and public water sector of the region will pursue the professionals graduating from the program because

of their unique and needed skillset. This future generation of water professionals should enhance sustainable water management in the Eastern Mediterranean.

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

The PARADOX Project - Innovative training approach in the technology-assisted environment for water management

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ABSTRACT

Most European Union countries do not face serious water issues now but the impending climate change and apathogenic pressures make it imperative to take actions to achieve sustainability for the future. The PARADOX project aims to modernize and reinforce education offered by traditional industries in the water sector. This was accomplished by gathering real-life studies, development of learning material, training modules, networking and training with targeted stakeholders. Specifically, six modules on cutting edge water topics were developed that were placed on an online platform. These models were tested and conducted by students and other stakeholders during six multiplier events. The feedback from these events helped improve the user-friendliness of the platform and the training module material.

Keywords: Water Sector, Climate change, Anthropogenic Pressure, Modules, Online Platform

1 Introduction

Issues and concerns associated with “Water” have been exacerbated in Europe due to climate and anthropogenic pressures [1,2]. The lack of adequate freshwater supplies is a main reason that hinders the economic development and social welfare of countries and regions [3,4]. In the Europe and especially the southern region, climate change is expected to negatively affect the quantity and quality of water resources [5,6]. Global, regional and national studies have shown an increase in mean and extreme temperatures as well as changing precipitation patterns [7-9]. The continuing forecasted trend towards decreased and more intensive precipitation events along with increased evapotranspiration due to the elevated temperatures, combined with the increased anthropogenic stressors, will substantially reduce water availability [10,11].

The impact of climate change on water availability and water quality will affect many sectors in Europe, including energy production, infrastructure, human health, agriculture and ecosystems. Staff qualifications, the inability to attract young workers remain one of the crucial points in Europe.

To achieve water resources security and sustainability in the Europe under these new environmental and social conditions, science-based and well-trained professionals specialized for the environmental conditions of the region that know how to conserve and eliminate the waste of water and consider potential climate change impacts are a requisite. PARADOX will trigger modernization and reinforce education aligned with the needs and opportunities offered by traditional industries in the water sector. It will provide, assess, and look for the recognition of basic skills needed in the water and environmental-related sectors. PARADOX will also address transversal skills, such as entrepreneurship, foreign languages and digital competences. the students and staff, and also everyone involved in the development of this initiative will have the chance of increasing their sense of initiative and entrepreneurship, their competences in foreign languages and, of course, increasing their skills and capabilities for employability in an industrial sector which is the main key driver in many European regions.

2 Water Sector Around Europe

One of the key priorities for Higher Education is the reinforcement of the "Knowledge Triangle", through the support of innovation, entrepreneurship and university-business cooperation. This specifically applies to those traditional sectors, such as the environmental-related sectors, where changes in education and training are required to equip the future workforce with the new skills for the new demands. Demands that are generated by the changing patterns of economic growth as a result of climate change and other anthropogenic pressures (e.g., water sources, tourism impact).

Nevertheless, the European Security and its Water Sources is a key driver of sustainable growth with a significant contribution to Europe's overall economic health, competitiveness, creativity, innovation, employment and growth. Staff qualifications along with youth unemployment remain one of the crucial points in Europe. To boost the recruitment of highly prepared staff requires initiatives addressing training to make the sector attractive and capable of transforming both the academic knowledge and high-level basic and transversal competencies required to be useful and applicable. For these reasons, this Strategic Partnership proposes the creation of a flexible learning pathway in line with the needs of learners and companies. This will enable to meet he environmental targets and securing sustainable conditions for EU citizens. It will provide a joint study modules program supported by Industry 4.0 and Blockchain certification application that will capitalize companies with prepared youth, providing enterprises innovation, expertise, and added value.

3 PARADOX main activities

The four main activities in order to meet its objectives are the following:

Studies of real-life. A comparative analysis, and evidence-gathering, of studies of real-life cases in order to have a real idea of the needs of skills and competences in the European Environmental Studies was confuted.

Modules and integrations. A joint modules' training curriculum with the integration of different learning modes (supported by Industry 4.0 and Blockchain certification) was developed.

Learning and training materials. The creation of learning and training materials together with methods, pedagogical approaches and tools were created.

Networking and training. This included the main capacity buildings and networking activities. The result of this activity developed a Study Report on current skills needs on the European Environmental studies and offers a Joint Training Curriculum together with learning content and an e-Learning platform that is freely and widely distributed. This activity also involved six Multiplier Events at the end of the project in order to disseminate the results.

4 Educational Material

4.1 PARADOX innovative modules

The consortium developed six modules (Table 1). The modules are for the Master's level. The teaching material include a PowerPoint presentation and written chapters on the topic of the module. Further, a brief description of each course is provided below.

Module 1 - Governance and Management of Water Resources: The course introduces students to the fundamental concepts of the nexus approach and presents an analysis for food production and distribution, water and energy management, focusing in arid and semi-arid areas.

Module 2 - Water Resources Exploitation in An Island Context: The main goal of this module is to show the students the importance of the responsible use of natural resources in islands, especially water, a very important, yet though a very scarce good on such isolated territories.

Module 3 - Sustainability Reporting: Water Management: Describes the circular economy and sustainable business models and the GRI standards and sustainability reporting

Module 4 - Sustainable Water Management Indicators: The main goal is to be able to assess water resources and use through sustainable water management indicators. Specifically, the Water Sustainable Development Index (WSDI) will be taught.

Module 5 - Ecohydrological and Ecosystem-Based Approaches and Nature-Based Solutions: The main goal of this module is to show the students the importance on sustainable water management that can be achieved with environmentally friendly approaches including all stakeholders. These include: Integrated Water Resource Management, Ecohydrological Approaches, Ecosystem-based Approaches and Nature-based Solutions.

Module 6 - Governance and Management of Water Resources: The main goal of this module is to approach to the hydrological engineering in terms of the hydrological cycle, and we will study the main hydrological processes and their applications as water bioengineering.

Table 1. The six training modules of the PARADOX program

MODULE
MODULE 1: GOVERNANCE AND MANAGEMENT OF WATER RESOURCES
MODULE 2: WATER RESOURCES EXPLOITATION IN AN ISLAND CONTEXT
MODULE 3: SUSTAINABILITY REPORTING: WATER MANAGEMENT
MODULE 4: SUSTAINABLE WATER MANAGEMENT INDICATORS
MODULE 5: ECOHYDROLOGICAL AND ECOSYSTEM-BASED APPROACHES AND NATURE-BASED SOLUTIONS
MODULE 6: ENGINEERING HYDROLOGY

4.2 PARADOX Platform

The new modules are available through the PARADOX Platform (https://paradox.web.uma.pt) (Figure 1). The portal contains all of the information regarding the new modules and is the main repository of the learning mate-rials. It also includes e-mailing abilities, discussion groups, and offers the possibility of being tailored to each modules needs and particularities. In order to have access participants need to register.

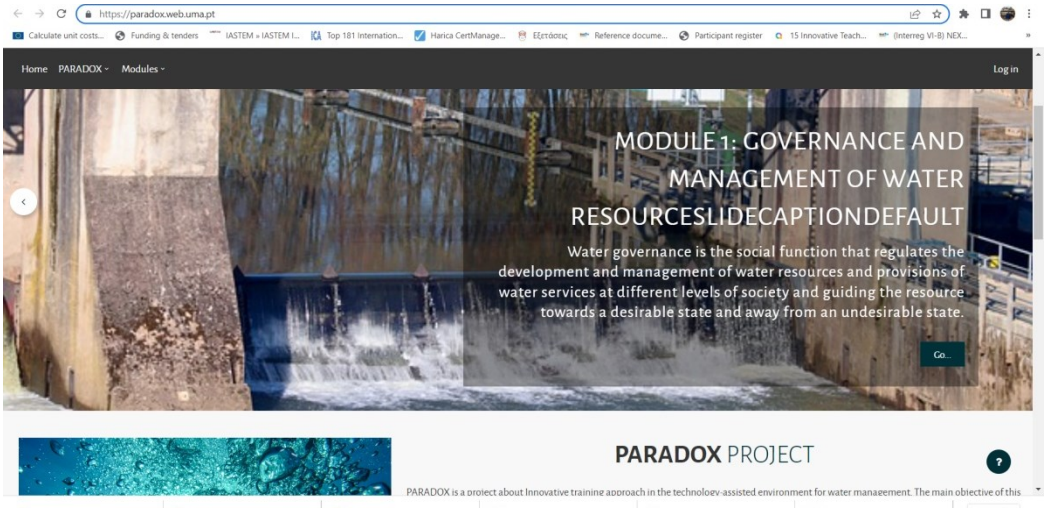

Figure 1. The main interface of the PARADOX platform

5 Multiplier Events

An important activity of the project were the dissemination activities since they ensured the efficient and effective promotion and sustainability of the project. One of the main activities are the multiplier events. These events showcased the work that had been done. By sharing results, lessons learned and outcomes and findings beyond the participating organizations enabled a wider community to benefit from a work that has received EU funding.

The multiplier events took place in order to assess the PARADOX platform. University students from different countries of the consortium were the target group. The students were informed on the project's goals and afterwards were introduced to the platform. Afterwards the students evaluated the platform in order improve the utility and user-friendliness of the presented teaching modules (Figure 2).

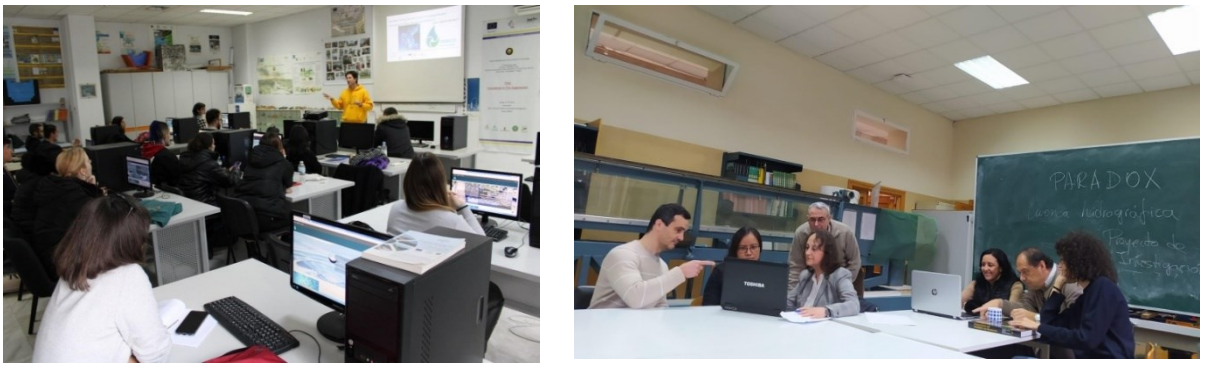

Figure 2. The students of the International Hellenic University, Greece (left) and Universidad Politécnica de Madrid, Spain (right) that participated in the multiplier event and evaluated the modules.

6 Conclusions

Sustainable management of water resources is and will become even more important in the European Union. This highlights the need for new professionals trained in new approaches and innovative tools to meet future needs based the climate and social conditions. The PARADOX project meting through the six modules and an online platform offers the necessary skills to the future workforce.

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Lagoon of Epanomi. Best practices for the sustainable management

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ABSTRACT

The aim of the project is to search for a semi-aquatic ecosystem and implement best practices for its sustainable management. The Epanomi biotope is of particular ecological, educational and aesthetic interest. It is a typical northern ecosystem that has been preserved almost in its natural form when the wider area has been degraded. The history of the name and the geographical location of the wetland define the spatial boundaries where human activities have affected it. Moreover, the area has enormous ornithological value, as its diversity provides the basic needs of migratory birds from north to south. Over time, the habitat of many organisms is disappearing as human activity increases and the area is subject to mismanagement by farmers and investors. The road to sustainable management of wetland and terrestrial ecosystems is long and difficult, but interdisciplinarity and wise land use can pay off for the environment in combination with best human practices.

Keywords: Lagoon, Epanomi, Wetland, Best practices, Sustainable management

1 Methods

Research in non-scientific sites for general information (wikipedia, local articles) scientific sites (google scholar, scopus), govermental sites (europa.eu, natura 2000).

2 Results and Conclusions

Coastal zones are important functions for the economy, transport, housing and recreation, which depend on their natural characteristics, pleasant landscape, cultural heritage, natural resources and richness of marine and terrestrial biodiversity. They are elements of National Environmental Parks with restrictions on their management. The importance of protecting coastal lagoons is manifold. The area can play an important role in the environmental education of county residents with guided tours of the wetland and boat trips to the beaches.

The Cape of Epanomi will be a place of new practices and all legislation for the protection of wetlands and biodiversity areas will be implemented. Sustainable management of wetlands ecosystems is difficult, as human activities, in addition to biological factors, must be taken into account. Best practices for land use can offer much to the environment in relation to human activity.

Acknowledgements: Professor George Zamis for his continuous support and guidance during the research, as well as the opportunity to present the results of my work at the conference.

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

Hydrological Forest Restoration - A Nature-based Solution

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ABSTRACT

The Mediterranean basin is subject to periodic flooding, reflected in material losses in housing, infrastructure, and crops, as well as in human lives. The current rainfall pattern is characterized by extreme torrential rainfall, short in duration but of great intensity, which has affected a society that is often unprepared to cope with these natural risks. In Spain, Hydrological Forest Restoration (HFR), understood as engineering project, has been applied since the 19th century as an effective tool against problems related to torrential rainfall in different geographical scenarios. There are numerous examples because of the application of certain actions integrated in these projects, both on slopes and in watercourses, which have provided an improvement in erosion control, a better distribution of water in the basin and a lamination of peak flows in storm hydrographs. Over time, this tool has been used in other basins, which has allowed for an integrated intervention from the headwaters, the gorge and finally in the final sedimentation section, with significant improvement in the management of water resources. To this end, Nature-based Solutions (NbS) have been applied, such as bioengineering techniques, both on the riverbanks and on the slopes that form the basin.These NbS offer advantages, not only in flood control and erosion control, but also in the improvement of surface and groundwater quality, the implementation of silvicultural treatments, and others that indirectly lead to the improvement of habitats, reduction of invasive species, adaptation to climate change and reduction of CO_2 emissions into the atmosphere.

Keywords: Hydrological Forest Restoration, floods, storm basins, erosion, NbS

1 Introduction.

The history of the management of watersheds in Spain dates to the early twentieth century when forest engineers specializing in the work of correction of torrential channels had to reconvert to work on slopes of basins affected by torrential geodynamism. Its effects were manifested on its slopes and channels both by sudden floods and by meltings of the snow cover and avalanches, as well as mass movements where landslides and rockfalls were frequent in terrains devoid of vegetation with which to reduce and control their effects.In Spain there are numerous examples of action from the Pyrenees to the direct basins to the Mediterranean Sea from Catalonia to the Southeast with its various extreme manifestations of historically disastrous consequences with the loss of human lives and goods near floodplains both in urban infrastructures and agronomic goods.

For all these reasons, Hydrological Forest Restoration (HFR) has been fundamental as a methodological tool and has been applied by extension in other degraded basins that needed a structure with which to tackle the work necessary to reverse the situation. From those first works in the headwaters of the Pyrenees in the correction of torrents, work has been carried out in other headwaters of basins with very different characteristics, but with a structural

scheme that has served as a work chronogram. This technique has provided great examples that can be seen today in a very different way from what they were originally. The examples presented in this communication are intended to draw attention to places that may present a problem of natural risks similar to the Spanish ones in the Mediterranean basins with numerous 'wadi' torrents that are very active and which could be controlled by applying a series of contrasted techniques.

It is clear that the technical solution to achieve these objectives involves a suitable combination of hydraulic measures for civil works and forestry in the maintenance of permanent tree cover in strategic places in the basin, normally headwater areas of the basin with steep slopes [10]. In this way the attenuation and control of runoff can be controlled by avoiding the extraordinary flows of high return periods which are thus attenuated and, therefore, laminating the water flows to the valley areas [10]. The techniques used on slopes and riverbeds have been based on what is known as the Basin Correction System (Figure 1), on the one hand with a series of forestry techniques used to try to control erosion in its different variants and, on the other hand, the location of barriers in torrential riverbeds, in order to control, retain and consolidate unstable banks. The materials used in these techniques were based on the use of techniques known in traditional forestry and the materials used consisted of local rock and wood, in most cases.

The European Commission now defines NBS as "solutions to challenges facing society that are inspired and supported by nature; that are cost-effective and provide environmental, social and economic benefits; and help to increase resilience". This definition integrates a large part of the actions that have been implemented over time in HFR projects for more than 100 years in many scenarios in Spain. These forestry engineering actions have been designed to protect the soil against erosion, attenuate floods and their effects on dominated areas, improve the distribution and quality of water in the basin, protect direct springs in reservoirs, and protect the water quality of the watersheds, among others. The great Spanish examples are diverse in each of the mountainous areas with a problem associated with torrential geo-dynamism, from the alpine-type torrents in the Pyrenees to the 'wadi' torrents (ramblas) in Eastern Spain from Catalonia to the South-East coast in Almeria and Granada.

Work on these torrents began at the beginning of the 20th century, as is the case of the Arratiecho torrent (Figure 1), when forestry engineers began restoring it by means of work on the riverbeds and slopes in the first decade of the 20th century. Nowadays, its slopes are populated with native vegetation and walls and dykes that blend in with the surroundings.

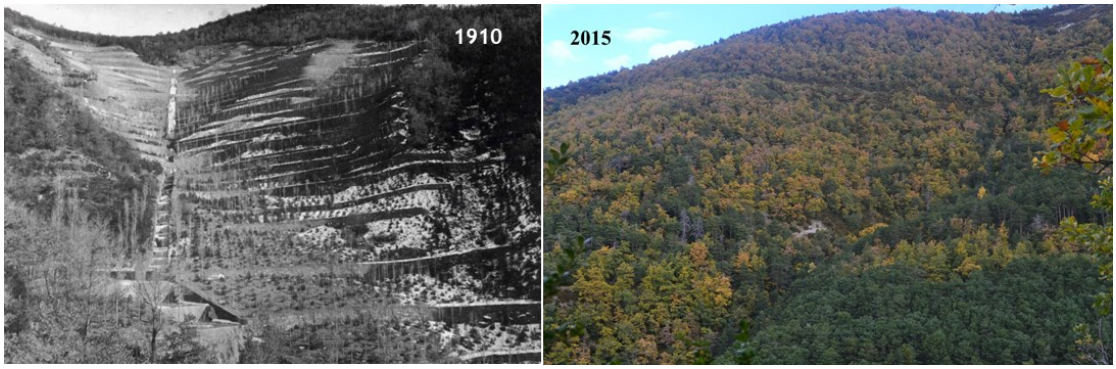

Figure 1. Corrective system of a torrential watershed (adapted from [4])

Corrective system of a torrential watershed					
Location		**Characteristics**			**Objetifs**
	Biological actions		canopy covers		Erosion control, interril and rills
			Aforestation		Increase infiltartion and control of direct runoff
Hillslopes	Mechanical Practices		Terraces		Erosion control, sheets and rills
			Drainages		Soil moisture control
					Mass movements control
	Small check dams		check dams (0,5m)		Gullies control
			Fascines		Erosion control
				Consolidation dams	Equilibrium profile
					Consolidation of river banks and slopes
				Retention dams	Total — Sediment retention
	Erosion area	Transversal works			Selective — Partial retention
					Defence of infrastructures and installations
In the torrential channel				Rocks chutes, stilling basins, aprons,...	Bed erosion control
				Vegetation covers and revetmer	Defence againts lateral erosions
		Longitudinal works		Groynes	Velocity control
				Walls	Defence river banks and rectification of hydraulic axis
	Sedimentation area			Sills	Protection of bed againts erosion
		Mixed works		Weirs, dispators, rock chutes,...	Concentration of water in a chanel fixed and stable
In the river channel		Longitudinal works		Revetements and groynes	Defence of river banks againts laterla erosions
				Rip raps	Defence againts floods and rectification of hydraulics axis

In case of Mediterranean wadis (ramblas), work has been carried out in an environment with semi-arid and arid climates that have led to the introduction of species that are not very demanding with water both on slopes and on riverbanks and riverbeds. Pine species such as P. halepensis together with 'tarays' and 'oleanders' have been widely used with good results, using land preparations related to runoff harvesting techniques such as overturned terraces and small watersheds in order to optimise the water supply to the plant.

Figure 2. Sierra Espuña. Two aspects separated by 100 years in Collado Bermejo, in the upper Espuña river basin. (Source: INIA and Tragsa)

Among the great examples that can be cited is the restoration of Sierra Espuña (Figure 2) as a whole, which began in the first decade of the 20th century with the work of the engineer Codorníu, considered to be the apostle of the tree. In that area, black and white photos showing a totally degraded environment can now be exchanged for those of the current Regional Park, undoubtedly a sign of a radical change in the physiognomy of the environment.

Nature-based solutions (NBS) were already in use in the 19th century but were not given their present name. This worldwide interest has gained interest in recent times with the use of more environmentally friendly materials and techniques. Foresters in Spain and by extension in Europe already knew what it was like to work with these techniques (Figure 3), as Thiery shows [8].

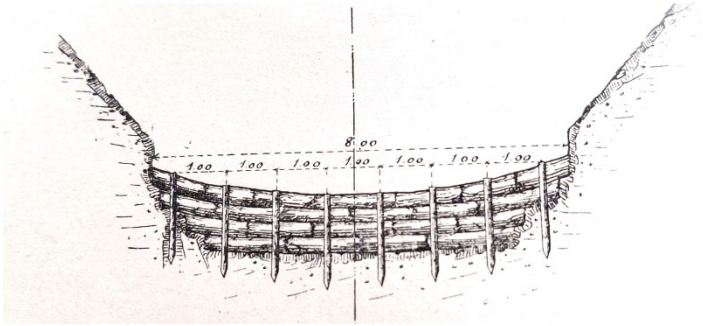

Figure 3. Wooden check dam on torrents in French (Source: Thiery [8])

Therefore, it is necessary to go back to the origins and find out what techniques and materials were used, using them with new methodologies both in the design and in the implementation on site by means of new machinery that facilitates the carrying out of restoration work on riverbeds and slopes.

2 Materials and Methods.

Spatial planning has been used since its beginnings as a discipline at the service of the resolution of urban planning problems, mainly in the management of industrial and urban areas. The extension to forest land with a strong natural component or agro-silvo-pastoral uses,

justified the appearance of the so-called Physical Planning, which essentially consists of the study of a territory oriented to follow a better use of resources [1], and where the consequences derived from this use result in an improvement of the quality of the natural environment [2].

In the 1970s, the numerous international conferences related to environmental degradation gave rise to a worldwide awareness of the orderly use of natural resources (water, soil and vegetation) within the physical framework defined by the river basin. In Spain, this concern was reflected in numerous laws and royal decrees that served as a lever to promote actions in different degraded systems in arid and semi-arid Spain, as well as in those places where torrential geodynamic caused serious damage. From the beginning of this work, the engineers were aware of the adversities that Spain presented in terms of both its relief and the irregularity of rainfall over time, but today they are further aggravated by climate change and the phenomenology must be re-evaluated as the effects of the floods are expected to be greater in Spain and, by extension, in the European Mediterranean basin. The methodology used is the HFR and its structure is shown in Figure 4. As can be seen, there are two distinct parts, on the one hand the descriptive part of the basin and on the other the purely hydrological part, which concludes with the estimation of peak flows for different return periods.

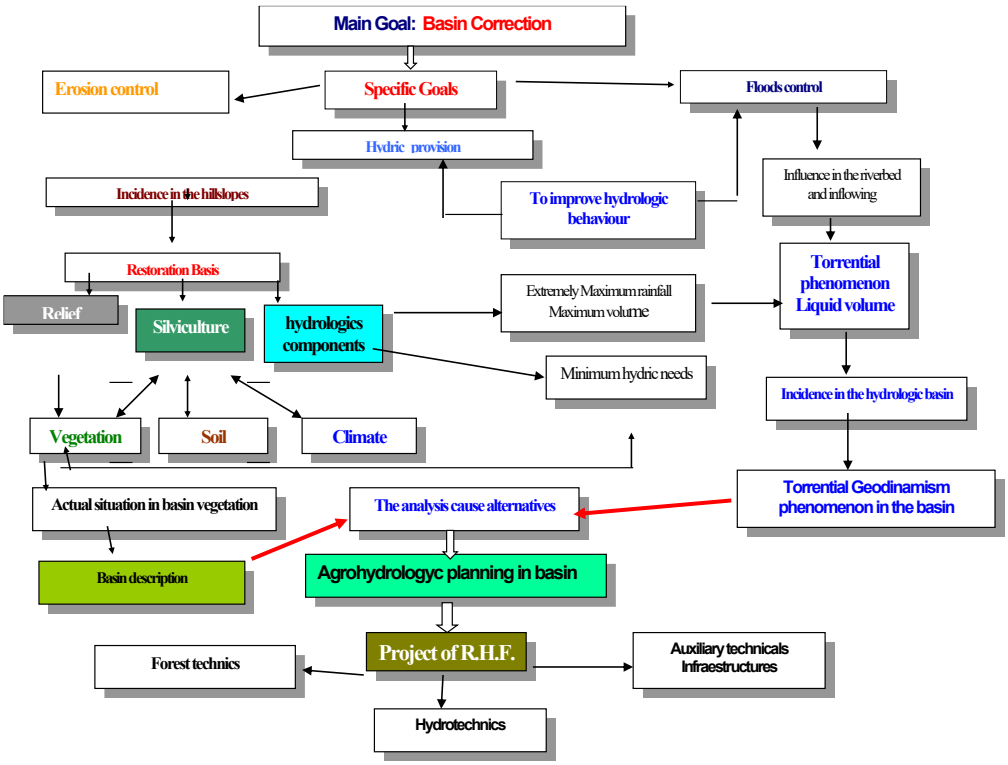

Figure 4. Framework of a RHF (Source: [3])

As can be seen in this scheme it should be underlined that before making the proposal of the real HFR engineering project there is a very important part in this structure: Agrohydrologyc Planning Basin (APB), which consists of land management but in this case in a specific basin.The planning process involved in basin APB must integrate the definition of objectives, the inventory of resources, their analysis and diagnosis, and the selection of the different instruments that are effective in achieving the objectives [4]. The three main actions can be summarised as; Forest management and technics, Hydrotechnics in channels and other auxiliary technical and infrastructures.

3 Results

In Spain, the implementation of these projects has decreased significantly since 2010, when the latest indicative figures for investments in forest hydrology are available. The policy carried out by the regional autonomous regions has not carried out as much work as in the past and everything is subject to investments against forest fires and fire restoration. Figure 5 shows how the rate is decreasing.

Recent investment figures are listed below:

- In the period 1985 - 2010, AGE - CCAA Collaboration Agreements
- About 765 million € in Hydrological Forest Restoration actions
- More than 460,000 ha of action (Restoration, improvement and conservation of vegetation cover).
- More than 1,440,000 m^3 of watercourse correction works

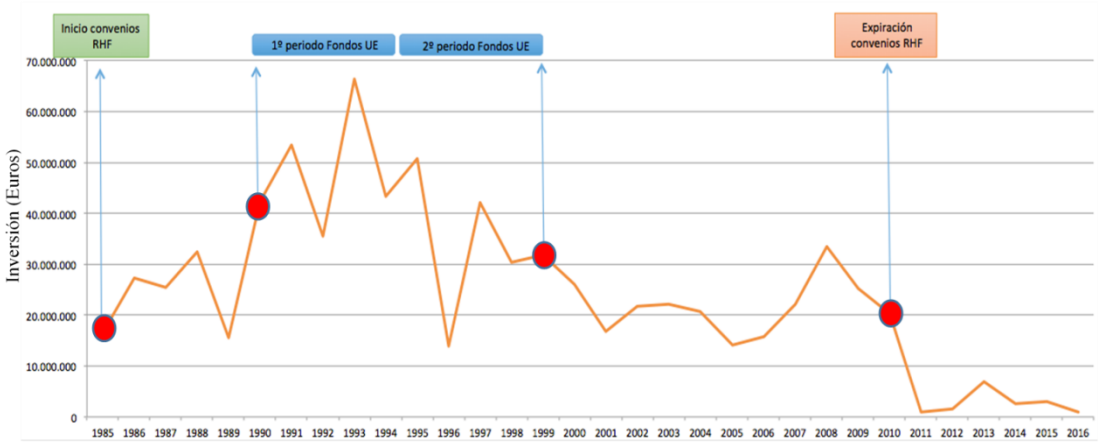

Figure 5. Graph of annual investments.(Source: Adapted of Ministery of Agriculture, Spain, [5])

4 Discussion

The forest cover conditions the water cycle in the basin, regulating the speed of runoff and increasing infiltration. The transpiration of the forest mass drives a certain amount of water into the atmosphere, closing the vertical component of the aforementioned water cycle in the basin, which begins with precipitation [6]. It is worth mentioning that the forest mass intercepts the vertical precipitation, from where part of it returns partially to the atmosphere by evaporation and on the other hand, by giving it up to facilitate the formation of horizontal precipitation.

Therefore, forest management is the instrument that manages the forest, in its most extreme expression of cover, over time, intervenes in the water cycle and consequently has an impact on water resources.

According to [7] several questions can be asked about the relationship of the forest to the water cycle when faced with APB:

1. Does the forest play a role in the formation of floods?
2. As extreme precipitation increases, are the effects of the forest in terms of flood control less relevant?
3. Does the forest control flooding in a catchment?

5 Conclusions

The conclusions that can be drawn from the current situation in the implementation of new projects will depend on the current policy of the Spanish Administration in which three main lines of action can be deduced:

- Planning: Priority Action Plan for HRH (PNAP)
- Execution: New agreements with local administrations, declarations of general interest and establishment of areas of Public Forest Domain
- Monitoring: Through the implementation of powerful Geographic Information Systems, monitoring of the main areas of action will be carried out.

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SESSION VI “PS4S-2023”- “Sustainability and Ecotourism”

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

Evaluation of bus-stops according to the distance from the water resources.

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ABSTRACT

This study presents the implementation of geographic information systems in order to perform as spatial analysis and restructuring of the bus-stops in relation to the hydrographic network. It is focused on the urban public transportation network of the Regional Unit of Thessaloniki. Specifically, the hydrographic network was produced via the SWAT hydrologic model in ArcGIS and, afterwards, the buffer zones of 20m along the streams, lakes and sea were developed. This process highlighted the bus-stops that are located in these buffer zones. These areas need to be further examined and validated via field visits in order to get high spatial accuracy. After being verified and deemed necessary, the new locations of the bus-stops can be finalized taking into consideration not only the Highway Code but also other parameters such as slope, landcover, soils, slope, traffic accidents and population density of each region.

Keywords: buffer zones, proximity, road network, spatial analysis, stream network

1 Introduction

Urban flooding is the inundation of land or property in a built environment, particularly in more densely populated areas, caused by rainfall overwhelming the capacity of drainage systems, such as storm sewers [1]. Flooding in urban environment depends on various parameters such as: a) conditions of storm sewers, b) obstacles of varying shapes and length scales, c) existence of ground floors and basements storages or parking zones in the buildings, d) the complex geometry of the city, etc. [2]. During strong storm events, the majority of the flow passes by the streets and the junctions [3,4]. The settlements, hospitals, schools, roadways and airports are considered as crucial elements of public infrastructure or facilities [5]. Bus stops are part of the urban network furniture and they are considered to be influenced in such conditions. In flooding conditions, residents experienced difficulties such as leaving/returning home and accessing transport services or other key urban infrastructure. These mobilities/immobilities vary by age and gender [6]. Flood risk has been considerably increased in Greece as 545 events were recorded, causing 686 human casualties and inflicting extensive damage across the country during the last 130 years in Greece [7]. A strategic plan and proper design are needed in order to deal with this new urban reality; this will allow decision-makers to monitor the status of the transportation network in real time and providing insight on how a critical event, such as a flooding, could affect it [8]. In addition, targeted bus-stops could act as pick-up points inside an evacuation zone to transfer people to shelters outside this area by using a pool of buses for the specific reason [9]. Moreover, the alignment and encroachment of channels for protection against flood risk seems to be the main cause of longitudinal hydro-morphological changes [10]. The specific zones, close to urban streams/torrents, may face the risk of flooding and even catastrophic landslides [11]. For all above reasons, the specific study concerns the spatial

analysis of bus-stops and the identification of those which are located close to hydrographic network in order to investigate their conditions and further examined if there is a need of relocation.

2 Materials and Method

The study area is the Regional Unit of Thessaloniki which covers an area of 3.683 km^2. The Greater Thessaloniki Area (GTA) consists of the City of Thessaloniki and the nearby municipalities [12]. Thessaloniki is the second largest city in Greece with a population in the metropolitan area of 1,006,730 residents in an area of 1,455.62 km^2, according to the 2011 census [13]. Thessaloniki's population density is very high, especially in the city center, at 20,429 inhabitants/km^2, with an average 8,000 inhabitants/km^2 in the sub-urban zone, and 971 inhabitants/km^2 at the metropolitan area. The Thermaic Gulf is located at the west side of Thessaloniki while a mountainous terrain rises on the north and east. The hydrographical network that drains the town of Thessaloniki starts from the surrounding hills forming small or large torrential streams, which once crossed the urban area ending in the Thermaikos gulf. The land-use changes and urban sprawl have created many problems due to the changes in the torrential environment of the region [14]. Thessaloniki is a very densely built area, within which several streams or stream parts are "hidden" [15]. The largest stream network of the city is Dendropotamos, followed by the torrents of Konstantinidi, Ano Toumbas, Kipou tou Kalou, Agios Panteleimon and Eleona [16]. Because of the geomorphology, the city center is along the coast, with an abruptly elevated upper city, connected to the Suburban Forest "Seih-Sou". This is also the reason why the road network and the connection between east and west urban areas is limited [17]. The 23.4% of the transportation network length in Thessaloniki is located in the flood extention zone [18]. Despite of this, GTA is not prone to major floods. The city suffers by damages caused by medium rain events caused in areas where slope changes abruptly or in areas where the sewage network is insufficient or near the coast where all rainwater is collected [19]. Thessaloniki Transport Authority (TheTA or OSETH), is the supervising authority of Thessaloniki's public transport system, under the jurisdiction of the Ministry of Infrastructure and Transport [20], while OASTH and KTEL are the operators of urban/interurban bus system (KTEL Thessalonikis S.A., KTEL Serron S.A., KTEL Chalkidikis S.A. and KTEL Kilkis S.A.) serving the rest surrounding locations in the GTA [21]. The location and implementation of each bus-stop is decided by TheTA while the Municipality is responsible for the construction/placement [22]. We firstly created a spatial database that includes the water basins according to the Water Resources Management Plans of Greece, the Municipalities, the land-cover, the soils, the slope, the accidents from 01/01/2012 to 31/12/2021, the historic flood events and the area prone to floods according to the Greek Ministry of Environment and Energy, the rivers, the lakes, the sea, the road network, the bus-lines and the bus-stops (Figures 1 and 2).

Initially, the hydrologic model (the SWAT model) was used in order to develop the hydrographic network of the study area based on the 30m Digital Elevation Model (DEM) that genderized the streams, the watersheds and the outlets of each watershed. Then, based on the produced stream network lake and coastal boundaries files, the buffer zones were created with 20m from each side. The final step was to highlight the bus-stops that are located within these buffer zones (Figure 3).

3 Results and Discussion

The previous described process resulted to 120 bus-stops within the buffer zones (20m) from water resources. This is the first-time attempt of such implementation, according to our current knowledge. There is a need to point out that these bus-stations do not mean that are dangerous for humans. It is necessary to evaluate the current bus-stops which are located near channels and their possibility being vulnerable in extreme weather conditions. Consequently, these 120 bus-stops need to be validated by field surveys in order to check different characteristics such as distance, topography, slope, landcover, soils, traffic

accidents, general conditions of the area in order to provide (if needed) another possible location. This is part of a greater redesigning project of Thessaloniki's bus-lines as a result of the new metro system starting operation.

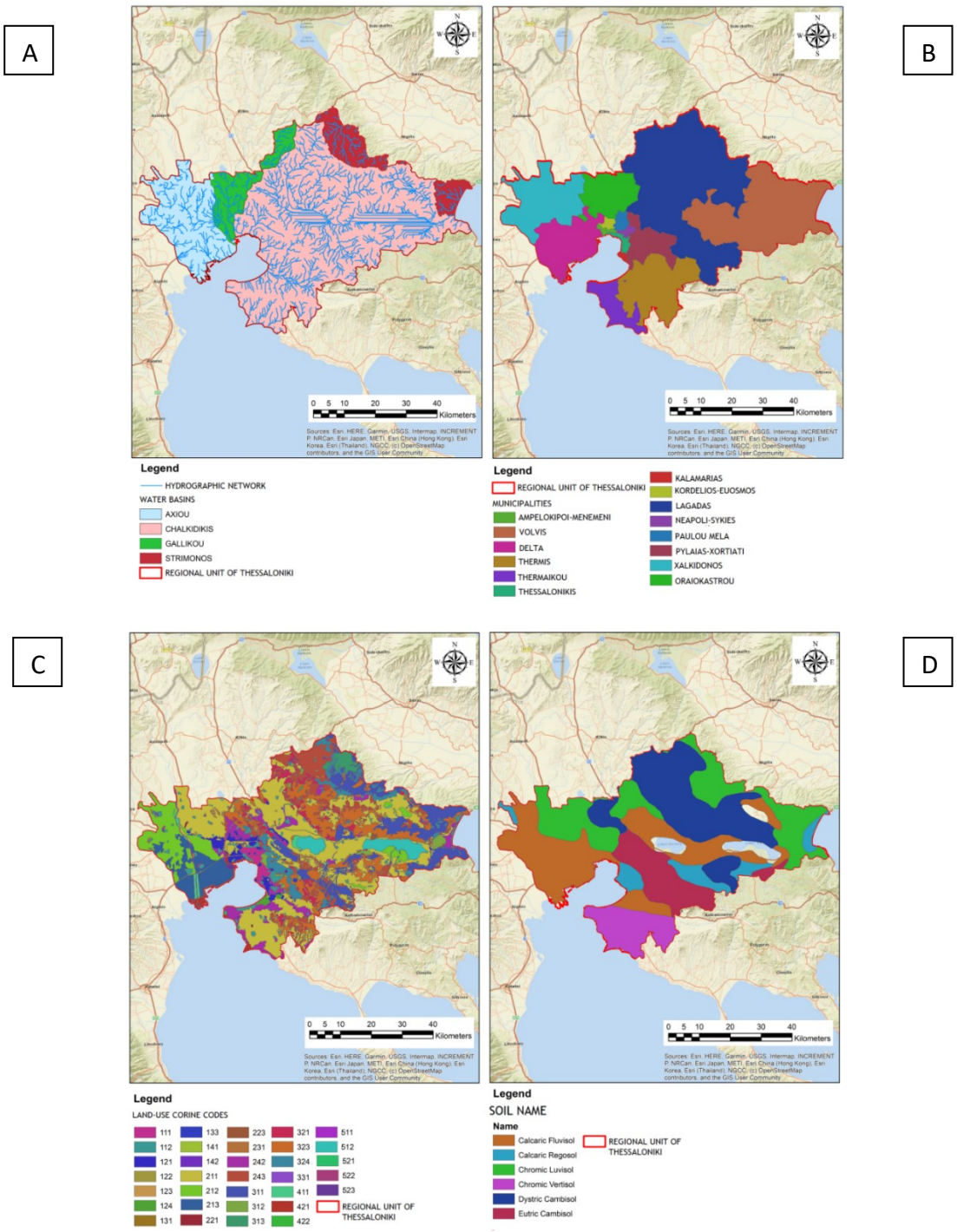

Figure 1. (a) The water basins and (b) the Municipalities, (c) The land-use codes according to CORINE classification and (d) the soil categories of the Regional Unit of Thessaloniki.

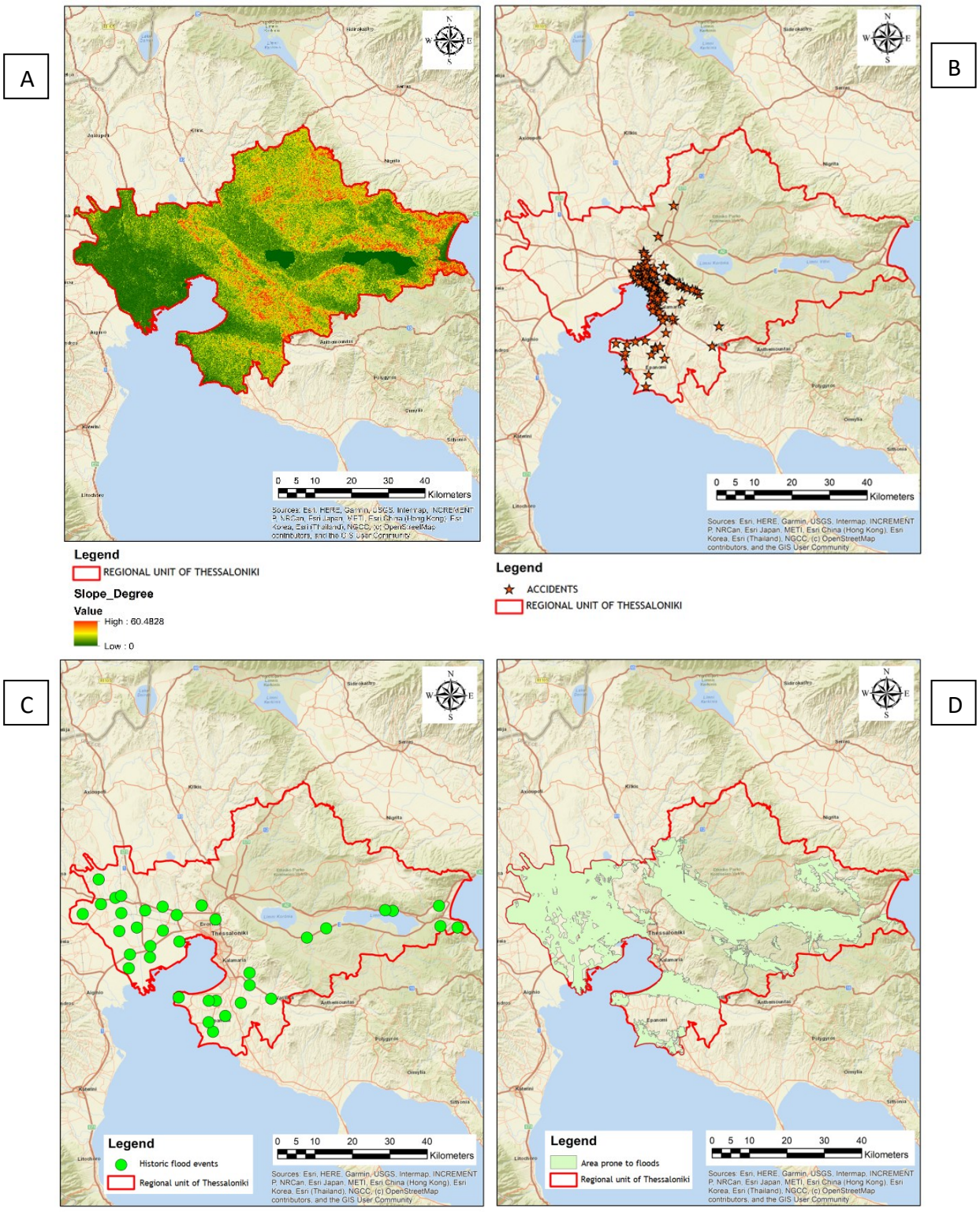

Figure 2. (a) The slope classification and (b) the accidents occurred (2012-2021), (c) the historic recorded flood events and (d) the area prone to floods of the Regional Unit of Thessaloniki.

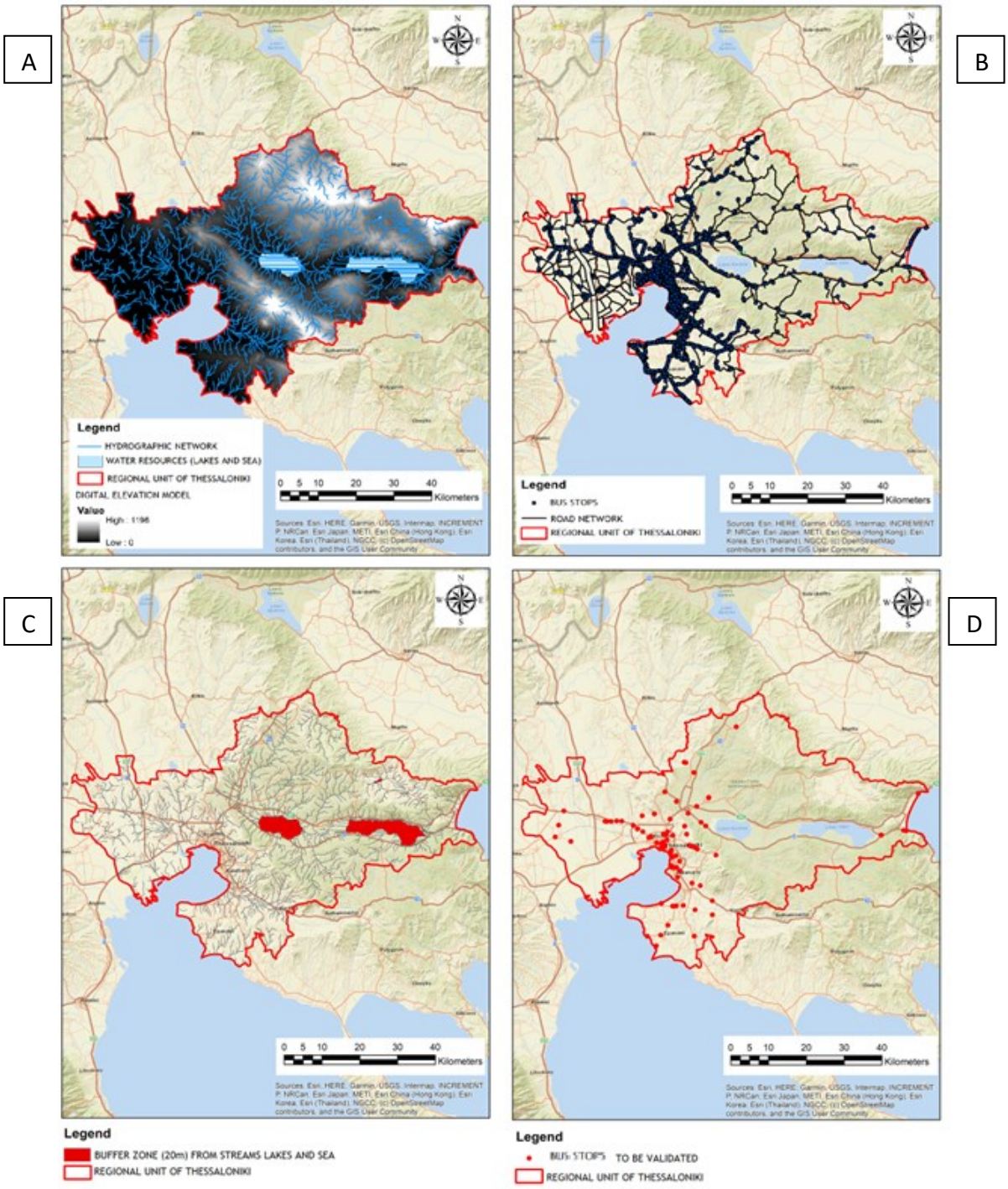

Figure 3. (a) The water resources and the modelled hydrographic network based on the 30m DEM in the SWAT model, (b) the road network and the bus-stops, (c) the buffer zones from water surface using 20m as a threshold value and (d) the resulted highlighted bus-stops located close to streams.

4 Conclusions

The spatial analysis in ArcGIS enabled to identify the bus-stops which are close (20m) to the water resources of the Regional Unit of Thessaloniki. The results should be verified by field visits. This methodology will be a useful tool for the Thessaloniki's Public Transport Authority and the design of bus system in relation to the operation of the Thessaloniki's metro.

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

"Philippi Park" - Protecting and strengthening the Cultural Landscape through Spatial Interventions

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ABSTRACT

"Philippi Park," a landmark of 8,000 years of history is underway in becoming a landmark destination to an international audience, as scheduled by initiatives of the recent administrations of the Greek government. The area of Philippi's cultural landscape envelops eighty-five villages and eight municipalities, Amphipolis, Drama, Kavala, Doxato, Pangaio, Prossotsani, Nea Zichni and Paranesti. It is defined as the Agro - Cultural environment centered around the peatland, which is the deepest in the world, stretching out to the Pangaion Hills and the mountain ranges of Falakro and Menoikio. The scientific organisation "Opsometha Eis Philippous" is an incubator of young and experienced scientists, which work on developing a continuous dialogue between citizens, professionals, local administration and academic and other knowledge institutions in this area for the past 6 years. In response to an open call for a Landscape Architecture Competition in Greece and Cyprus in 2021, a design proposal, that was produced by the organization's Architecture Team, won First Prize in the category of Urban Masterplan, addressing the following matters. Taking water as a key element, a framework of holistic approaches was set giving emphasis to competitive advantages and heritage highlights of Philippi. This paper traces the design process and framework suggesting structural changes as starting points towards the activation of social, cultural, historical, and environmental changes throughout the area. The area of interest and its relevance to recent and future developments is introduced, followed by a description of the design methodologies, and the design aspects of the landscape and planning proposal.

Keywords: Opsometha eis Philippous, Urban Metabolism, Urban Masterplan, Holistic Strategy, Water Network, Cultural Landscape, Social Cohesion, Unesco, Ancient Philippi, Ancient Egnatia, Amphipolis

1. Introduction: Philippi Park, a heritage site of historical significance

"Philippi Park", a landmark of 8,000 years of history, becomes a landmark/destination for the experiential daily life of the global civil society. The structure of the landscape enables us to highlight its parts, focusing on its competitive advantages (cultural, historical, social, environmental). Based on these, three proposals (standard models) were chosen, placed in the most sensitive part of the "Philippi Park", the Philippi bog, near the Ancient Philippi (UNESCO monument), the Ancient Egnatia Street and the Kasta-Amphipolis tumulus.

Figure 1. Site Analysis, source: Scientific Organization “Opsometha Eis Philippous”

The scientific organization "Opsometha Eis Philippous" as an incubator of young and experienced scientists, has been developing a continuous dialogue between citizens, professionals, local administration, academic and other knowledge institutions for 6 years. They conduct research, produce studies, design projects/actions/funding proposals and create friendship networks with the aim of: A) Mobilization of human resources, B) The recognition, protection and promotion of the rich environmental, agricultural and cultural wealth of the region & C) Cooperation with Greek and foreign universities - student theses (one of which is integrated in our proposed proposal) and PhD’s.

Their activity is fueled by the principles and results of the Feasibility and Sustainability Study - Master Plan "Philippi Park", completed in 2018. This Study was funded by the Municipality of Kavala and acts as a base layer for all further research, as it concluded a guide on 50 actions / implementations that lead towards the creation of unified networks of activation for the society, economy, environment and microclimate throughout the researched area of Philippi. In 2020 the thesis project “Regeneration proposal for the canals of Philippi Peatland – Connecting society with the rural environment”, in the department of Architecture of the University of Thessaly, by Foteini Katavelaki uses the Master Plan "Philippi Park" as the base for the final design proposal of three site spesific architectural implementations around the Philippi Peatland area.

The Master Plan "Philippi Park" and the thesis “Regeneration proposal for the canals of Philippi Peatland – Connecting society with the rural environment” were used for the conduction of the final submission for the First Landscape Architecture Awards

Competition, organized by the Panhellenic Association of Landscape Architects in 2021. The proposal won the First Prize in the category of Urban Masterplan, by describing the methodology of the research of the organization, focusing on the spatial and environmental aspects of its historical, cultural and social identity in the Philippi region.

2 Design Analysis Methodology

2.1 SWOT and Citizen Science workshops

SWOT analysis is a widely used strategy tool in planning. The first step is the "internal analysis" of the study area, which focuses on finding its strengths and weaknesses. The second step is the analysis of the "external environment", which aims at discovering possible risks or opportunities that exist. The findings of the SWOT analysis are summarized and are the basis for the intervention proposal.

Regarding the methods used, "Opsometha Eis Philippous" are using participatory workshops and people engaging events as a design and implementation tool. Based on participation, openness and cross-sector synergies, a model of participatory design process that will facilitate innovative solutions for Philippi Park is developed. Through participating in design, citizens automatically develop a sense of belonging, but also responsibility and commitment to the implementation and development of a project based on the common interest. As a result, the Identity of the Place will be formed as a living and adaptive network that connects and empowers all stakeholders involved in the design.

2.2. Stakeholders' identification and SDG focus

The strategic development model of "Philippi Park" proposes the creation of an integrated operating system to highlight the cultural and environmental profile and heritage of the region. Stakeholders of the area are part of this system and create relations with each other aiming in its development. The system includes citizens living in the area, farmers, scientists, investors, businessmen and visitors. Municipalities and local authorities are also part of the system and are collaborating with private stakeholders.

Using the United Nations Sustainable Development Goals as a guideline, the holistic development model aims at:

- circular economy
- healing the natural environment
- strengthening of cultural heritage
- implementation of 'button up' actions
- multilayered touristic development
- cooperation between public and private sectors
- sustainable development

All sorts of combinations of the established goals promote a circular and balanced model that focuses on the relation between the area's morphology and structure (urban and rural landscapes) and the most efficient and moderate use of its resources (natural or not). This model of "Urban Metabolism" is used in order to develop proposals (standard models) placed in the most sensitive part of the "Philippi Park", the Philippi bog, near the Ancient Philippi (Unesco monument), the Ancient Egnatia Street and the Kasta-Amphipolis tumulus. The water element is featured as a factor of promoting a) the Natural Landscape, by engaging with factors related

to health and wellness and b) the Cultural Landscape by promoting architectural features, social engagement issues and historical Landmarks.

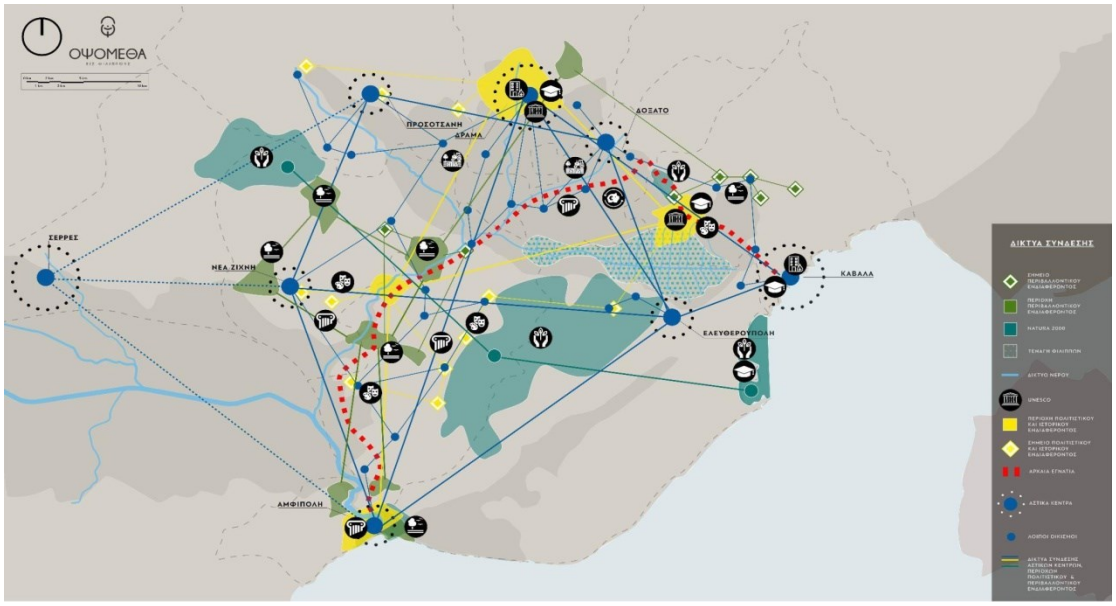

Figure 2. Vision, source: Scientific Organization "Opsometha Eis Philippous"

3 Water as the primary design element

In further detail, this project addresses the need to preserve and highlight the special cultural and environmental wealth of Philippi Park. It tackles issues such as water resource mismanagement, flooding, irrational agricultural practices in the peatland, and lack of connection with the UNESCO monument. As the Philippi Peatland is located in the center of the Philippi Park and is home to 127,000 people, it is an immensely productive area with remarkable cultural and historical value. The research, mentioned above, delivered essential conclusions about the social isolation of the landscape and its consequences from anthropogenic activity.

Three key proposals were put forth for the regeneration of the area and its canals with the intention of finding a balance between providing entertainment, education, and employment opportunities. The aim is to form an equitable relationship between the local community and the natural environment, by creating leisure and sports activities, alternative tourism, and tastings, enrich of the existing native vegetation, expansion and use of canals as an alternative form of transportation, as well as cycling, hiking, and paddling routes. The three building proposals consist of: A) Facilities for the management administrations of all Natura and the Peatland areas. B) A model for a Sports Center and C) A model for a Farmers Market. This preliminary infrastructure uses the water network of the peatland area and promotes its daily use for transportation, recreation and nature rejuvenation purposes.

4 Conclusions

The landscape of Philippi – Amphipolis turns into a set of complex networks that connect the urban centers and settlements with the points of cultural and environmental interest. The

interaction that takes place highlights the richness of the area and strengthens the character of the proposal and combines the production of agricultural goods, entertainment and recreation, education and sport into a harmonious relationship between people and nature.

The Strategic development model of "Philippi Park" aims to mobilize human resources, recognize and exploit the rich environmental and cultural sources of the region as a single rural-cultural environment promotes inter-municipal and interdisciplinary cooperation and intergenerational dialogue. So far, we only have very few outcomes on the way of implementation for all the interdisciplinary research that has been conducted.

Through the design process, local communities have had the opportunity to get to know each other, to recognize the common good that has been handed down to them, and to get excited through the contact with the place in which they live. Farmers get the chance to present their products, to feel proud by showing the beautiful place where they grow them and take part in the creation of new opportunities for their future.

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

From pollution to solution: Skimmer vessel a way to collect plastic waste. The Romanian pilot case study.

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ABSTRACT

Since its popularisation in the 1950s, the use of plastic has skyrocketed due to its benefits to society. As plastic waste accumulates in rivers, seas and oceans at an accelerating rate, effective and sustainable measures are needed. One of the solutions identified has been the development of technologies (depending on the type of plastic targeted-macroplastic, microplastic or both) that prevent plastic from entering waterways and the collection of plastic waste floating on the water surface.[1] Buzau-Ialomita Water Administration investigated within the Black Sea program (BSB963), Protect-Streams-4-Sea project, the composition and abundance of anthropogenic litter on the main course of Buzău river from the border with Covasna county and downstream to Pătârlagele town, including Siriu Reservoir. The most representative items of anthropogenic litter were plastics, with 93% abundance of all litter, the biggest abundance in Siriu reservoir. Due to the fact that one of the aims of the "Protect-Streams-4-Sea" project is to investigate and monitor pollutants (plastic waste) in the pilot area and in order to reduce the amount of plastic waste that reaches Buzău river, Buzau-Ialomita Water Administration has identified and purchased a special surface debris collection vessel to collect the macropastic floating on the surface of Lake Siriu.

Keywords: skimmer, plastics, collection

1 Introduction

The latest pollutant with a major impact on ecosystems and human health is plastic. Plastics make up the bulk of waste in rivers, seas and oceans. Numerous studies have shown that rivers are the main barrier for plastic transfer to the sea [2-5]. Once in the environment, especially in the aquatic environment, plastic waste (macroplastic, microplastic, nanoplastic) can persist for hundreds of years.[6].Plastic pollution is a global problem, whether in the world's oceans, seas or rivers [7-9]. Rivers have become an important route for the transfer of plastic waste from the population to the aquatic environment [8-9]. To this end, the Buzău-Ialomița Water Basin Administration, benefiting from funds allocated through the Black Sea programme (BSB963), has suggested to purchase specialised equipment produced for its own specifications, at national level. Its operation, under specific conditions, will reduce the quantities of plastics in reservoirs, which are then transported down rivers to the sea.

2 Materials and Methods

Buzau-Ialomita Water Administration analyzed the types of plastic waste collection technologies developed internationally. Based on the analysis of such equipment used at international level, a specification was drawn up with the technical characteristics of the equipment that would correspond to local conditions (lakes and rivers morphometry, debris characteristics, personal, waste storage system - mobile container with unloading gate,

corrosion resistant materials, docking and unloading system, transport capacity, propulsion options, consumption, minimum collection speed, travel speed (with load), equipment mobility, versatility, reliability, cost of acquisition) [11].

The aim was to ensure that the equipment could be transported on public roads in safety conditions, with all documents required for permanent registration in circulation, without the need for special permits (maximum load exceeding). Also, that loading and unloading of collected waste should be easy, that is easily serviced by a small number of staff, it has to be able to be registered by the naval authority (to obtain technical certificate for inland waterway and on-board certificate), be reliable over time and have a minimum maintenance schedule and low fuel consumption.

In order to use the equipment efficiently and to be quickly financially covered, an additional requirement was to transform the place where the collection basket is positioned into a foldable working platform so that it could be used for other specific water quality monitoring measures carried out by Buzău-Ialomița Water Administration. The specifications have been posted in the public procurement system following the specific procurement procedures. During the construction of the equipment, the representatives of the purchaser kept in touch with manufacturing company in order to clarify some technical aspects.

3 Results

The production technology consists in a catamaran-type boat, made of fiberglass and steel structures. Between the two floats is placed a stainless steel basket in which the plastics from the surface of the water are collected. This basket can be emptied with the help of a mobile crane on board the ship or on land, so that the loading-unloading operation is partially automatic. (Photo 2)

Photo 1. Skimmer vessel transport

Photo 2. Skimmer vessel operating

At the same time, instead of the collection basket, a deck can be installed so that the boat can provide a working platform for 2-3 people - interchangeable pod system (Photo 3).

Photo 3. Skimmer vessel with deck installed

The designed equipment has the following characteristics (Tabel 1):

Table 1. Skimmer characteristics

maximum length	6.50 m
breadth	2.61 m
height	0.7 m
empty vessel draft	0.17 m
full vessel draft	0.300 m
empty vessel displacement	1.29 tons
maximum displacement	2.29 tons
maximum number of people allowed on board	4
outboard engine	20hp
material	PAFS

4 Discussion

Identifying the optimal characteristics of equipment for collecting plastic waste from the water surface was difficult. Many publications indicate that mainly plastic waste is collected manually from the water surface or river banks [10], which the project team and volunteers did in July 2021 during an awareness raising event organized as part of the project. In this context, by implementing the BSB 963, “Protect-Streams-4-Sea” project, the possibility of financing the acquisition of such specialized equipment was identified, project implementation team establish the technical construction characteristics of this collecting floating waste equipment.

5 Conclusions

The amount of marine litter and plastic pollution is growing rapidly. Emissions of plastic waste into aquatic ecosystems are projected to nearly triple by 2040 without meaningful action [1,12]. Plastic waste is one of the most ubiquitous pollution problems affecting the world's oceans, seas and waterways. Given that rivers are a major pathway for litter including plastic waste entering the marine environment, there has been a growing emphasis on the tehnologies to prevent and collect them. Skimmer vessel have played an important role in the network of technological platforms used to collect plastic waste. The representatives of Buzău-Ialomița Water Administration have carried out an international project, accessing funds through the Black Sea programe (BSB963), to investigate the composition and abundance of litter

(macroplastics and microplastics) in order to efficiently collect plastic waste from reservoirs using innovative joint instruments - skimmer vessel. The boat was designed and produced in Romania, at the request of the beneficiary. It is expected to be exploited in the future with a view to determining its effectiveness as well as its technical improvement. When drawing up the specifications of the vessel it was taken into account that the equipment must be versatile, efficient, with minimum maintenance, easy to operate, with custom made trailer for launch and recovery. The efficiently collection of the annual quantities of waste collected from a given monitoring section can provide information on the management of waste collection within the river basin.

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SESSION VII “PS4S-2023”- “Remote Sensing and GIS Applications”

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

Using vegetation indexes to determine erosion areas in the Debed River Basin

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ABSTRACT

The article deals with the problem of determination of soil eroded areas using vegetation indicators. The focus of the study is the impact of modern land use on the erosion of the area. The degree of erosion of the areas considered in the article was identified and situationally analyzed through the indicators of vegetation. The obtained results were compared with the modern land use and the relationship between land use forms and the degree of erosion was revealed. As an example, the article discusses four considered sites (Shirakamut, Marts, Kurtan, Archis) of the Debed River catchment located in the northeast of Armenia. The selection of sites was based on the heterogeneity of ecosystems and the nature of land use. The studies were carried out within the framework of the "Protect-Streams-4-Sea" Programme.

1 Introduction

Soil erosion is a process occurring on the earth's surface, in which a whole complex of factors participates, the energy source of which is the sun. There are many factors of soil erosion in the Debed basin, each of which promotes or hinders the development of erosion, ultimately the intensity of erosion is determined by the whole complex of these factors. Among those factors, soil composition, atmospheric precipitation, slopes and orientations of mountain slopes, vegetation cover and nature of land use play a significant role. Depending on the vegetation, soil erosion can have an active or passive manifestation. Vegetation indices are widely used to study and evaluate the state of vegetation, which are calculated by the differences in the brightness of pixels in the images of the visible and near-infrared parts of the spectrum. In our study, the main focus was on the study of the distribution and dynamics of the vegetation index NDVI. One of the important areas of application of this index is the determination of the erosion of the soil cover of the area.

2 Methods

In the article, the study was carried out by the method of calculating and mapping the Normalized Difference Vegetation Index in GIS. Normalized Difference Vegetation Index (NDVI) quantifies vegetation by measuring the difference between near-infrared (NIR) and red light (Red). NDVI is calculated based on the following equation:

$$NDVI = (NIR - Red) / (NIR + Red).$$

NDVI values lie between -1 and +1. The higher the value is (close to +1) reflects high Near Infrared (NIR) which means dense greenery and healthy vegetation cover. The produced result depicts the NDVI index on a colorized scale from -1 (purple) to +1 (green). Dense and healthy vegetation corresponds to positive values, while clouds and snow are characterized by negative values of the index. Typical vegetation values range from 0.2 to 1. Healthy plants, which are in very good condition, are reflected in values >0.6. When the values of the index are at zero or very close to it, they correspond to the absence of vegetation.[1]

The study was done with a systemic and spatiotemporal approach. Based on the main objective of the study, high-resolution satellite images of the Debed River basin in different years and seasons were used[2]. Aerial photography of the target areas was also done using a drone.

3 Results

The vegetation NDVI index of the Debed River basin was calculated for different vegetation phases of 2021: spring, summer and autumn, and its annual average was estimated (Figure 1). NDVI indices were calculated using Sentinel-2 satellite images for May, August and November.

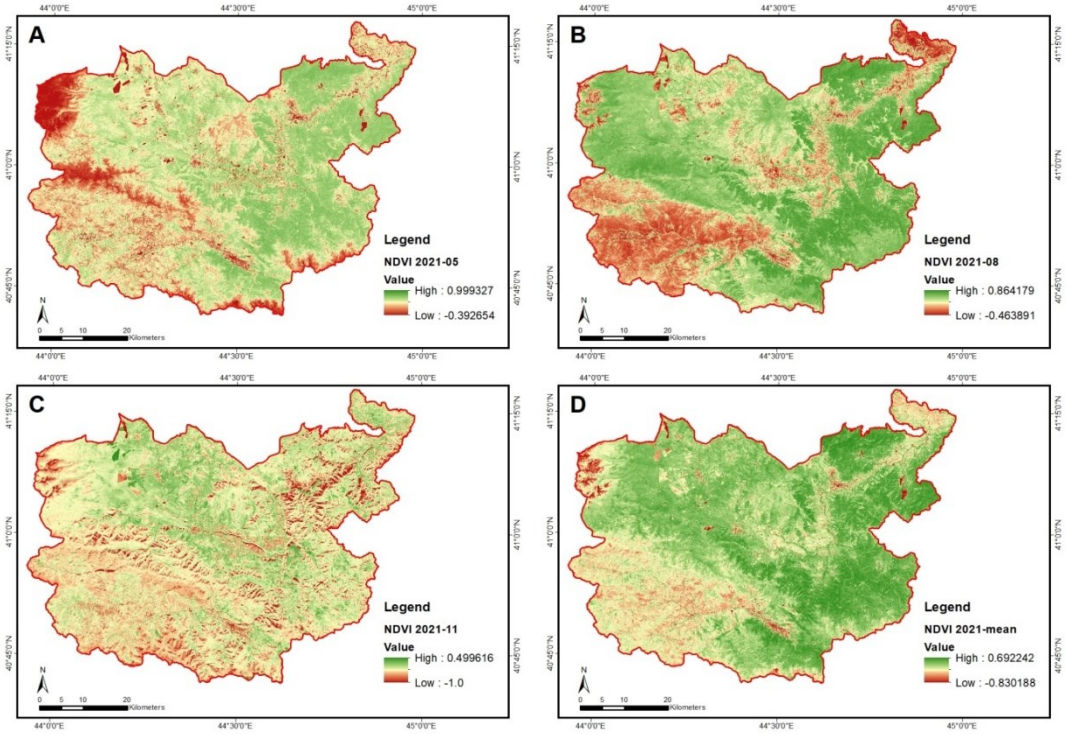

Figure 1. NDVI indices of the Debed river basin

The study determined the NDVI index of each precinct for the month of August 2021. The choice of the date depends on the purposeful use of the land in the area. This applies especially to agricultural lands. Accurate depictions of land use were obtained through drone

[1] Vegetation Indices Report (The Greek Pilot Area). PREPARED BY Protect-Streams-4-Sea Management Team (2022) 42 p. P 6.

[2] https://scihub.copernicus.eu/dhus/#/home

photographs taken during that same period. The obtained results are shown in Figures 2, 3, 4, 5.

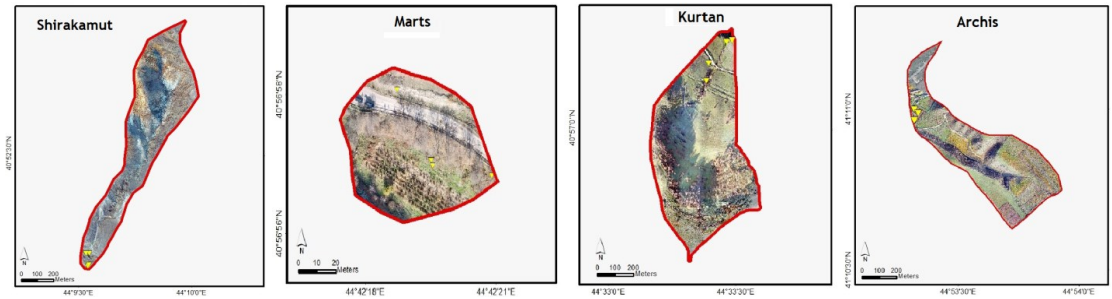

Figure 2. Very high resolution UAV ortho imagery

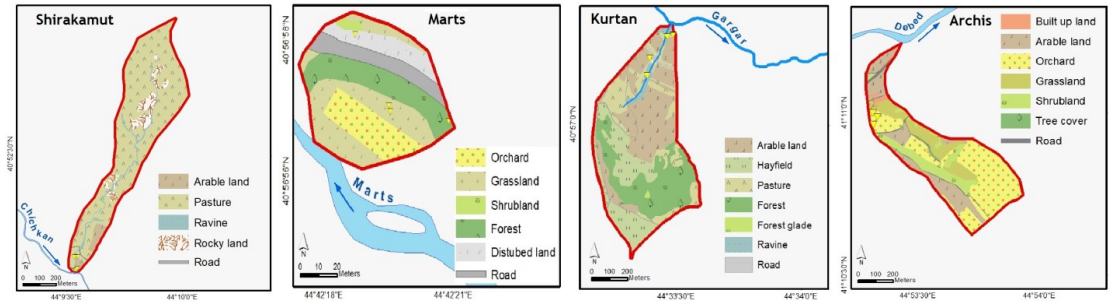

Figure 3. Land use Land cover

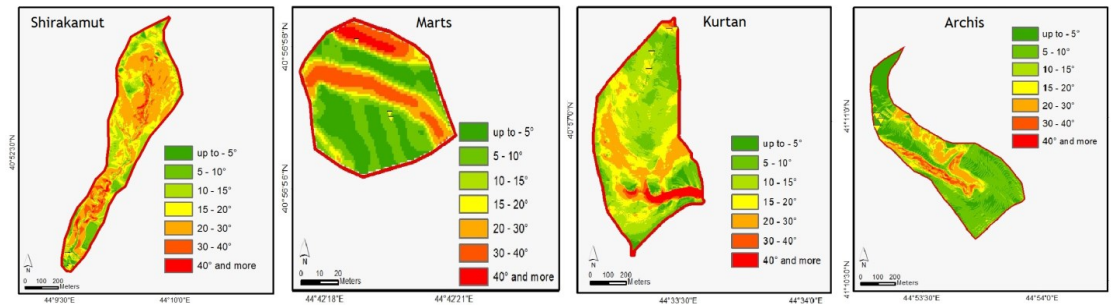

Figure 4. Surface slope by degree

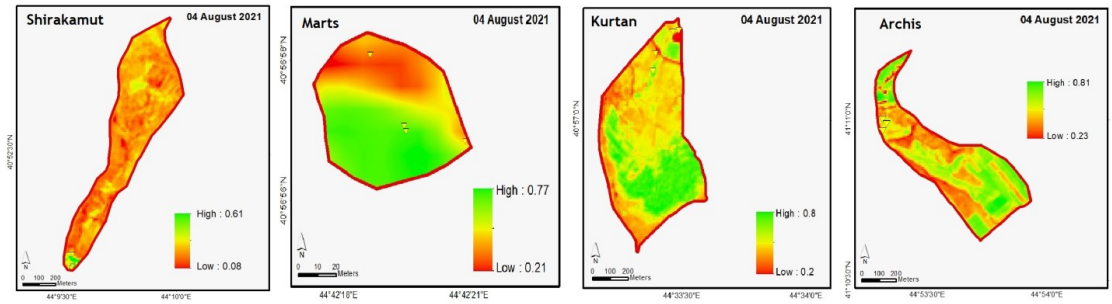

Figure 5. NDVI indices

Quantitative data of modern land use of the study area and magnitudes of anthropogenic disturbance are presented in Table 1.

Table 1. Land use and anthropogenic disturbance of the study areas

Land use (ha)	Study areas			
	Shirakamut	Marts	Kurtan	Archis
Arable land	1.6	-	14.4	7.1
Grassland/Hayfield	-	0.14	9.4	4.8
Pasture	29.8	-	7.0	-
Orchard	-	0.07	-	14
Road	0.1	0.05	0.8	1.0
Disturbed land	-	0.04	-	-
Built ap land	-	-	-	0.4
Shrubland	-	0.01	-	4.5
Tree cover/Forest	-	0.09	11.1	0.1
Forest glade	-	-	0.1	-
Ravine	1.3	-	1.3	-
Rocky land	2.8	-	-	-
Total	35.6	0.4	44.1	31.9
Disturbance (%)	88.5	40.0	71.7	70.5

4 Discussion

According to the seasonal assessment of the NDVI of the Debed river basin, it is found that the range of indicators lies in the following ranges: -0.392654 - +0.999327 in May, -0.463891 - +0.864179 in August, -1.0 - +0.499616 in November, and the average of the vegetation period is -0.830188 - + 0.692242 (Figure 1). The selected period corresponds to different phenological stages of vegetation in the study area, as well as land use forms and features.

According to the May NDVI data, the vegetation in the high mountain zone is weaker than in the middle and low mountain zones. This is explained by the stages of plant phenological development, which is subject to a well-defined upward zonation. Due to the nature of land use and types of natural landscapes, the middle and low mountain zones of the study area have mostly positive NDVI indicators, and the high mountain zone has negative NDVI indicators. Taking into account the fact that during the spring months in the studied area, abundant atmospheric precipitation is observed, it can be assumed that the upland zone, having a weak vegetation cover, is subjected to different intensity of erosion. Erosion processes are relatively weak in the middle and low mountain zones. In the spring, the

erosion process also activates in arable land that is not yet covered with vegetation (Figure 1).

In August, the meadow vegetation of the high mountain zone affects the NDVI, positive indicators become dominant. A certain change is observed in the middle and low mountain zones, an increase in negative NDVI indicators is observed due to agricultural activities: grazing of pastures, harvesting of grain fields and grasslands. However, in general, the NDVI of the middle and low mountain zones is influenced by the forest landscape occupying large areas, which determines the dominance of positive NDVI indicators. During that time, although the atmospheric precipitation decreases, soil erosion trends are observed in the vegetation-free areas of steep slopes (Figure 1). In November, positive NDVI indicators decrease widely, which is explained by the end of plant vegetation, as well as the final harvest of agricultural lands occupied by various crops and plowing of arable land. During that time, atmospheric precipitation increases and soil erosion becomes more active on barren mountain slopes (Figure 1).

Based on the NDVI data, the erosion trends and its intensity in the high mountain zone and areas of active agricultural land use become evident. It becomes more illustrative by combining the land use and NDVI data of the four smallest selected areas in the Debed River basin: Shirakamut, Marts, Kurtan and Archis. In order to have accurate results, by comparing the drone pictures, modern land use and surface slope maps of the studied areas with NDVI maps of the same period, a direct relationship between the amount of soil erosion and vegetation cover was found (Figure 1, 2, 3, 4, 5). The obtained results show the disturbance of the studied areas (Table 1). The analysis of the data in the table shows that about 67.7% of the land area of the study areas has been changed by man, that is, natural landscapes have been transformed into cultural landscapes.

5 Conclusions

Thus, the NDVI indicators of vegetation in the Debed river basin in different seasons of the year express the vegetation coverage of the area, which makes it possible to evaluate the spatiotemporal manifestations of the possible development of soil erosion. It also provides insight into land use patterns, especially agricultural land use, and thereby identifies eroded areas. The specific observations made in the study areas selected in the Debed river basin prove that NDVI indicators are important indicators for the assessment of vegetation cover.

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

A new streambank erosion index. Application in Aggitis Basin, Greece.

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ABSTRACT

Different factors such as the erodibility of soils, the landcover expressed via satellite imagery, topographical factors e.g., stream power index (SPI) and topographical wetness index (TWI), the rainfall erosivity index, the human-made constructions and finally the water yield (m^3/s) as generated by hydrologic modeling in order to develop a streambank erosion index in GIS. Furthermore, this index was validated by implementing a known field observation protocol, the Bank Erosion Hazard Index in specific locations. The index allows us to monitor hot spots in the stream and the streambanks at a large scale by using remote sensing techniques.

Keywords: streambank erosion, hazard, index, geographic information system, GIS,

1 Introduction

Stream bank erosion and deposition are complex phenomena that affect many people worldwide who live in proximity [1]. There are various methods and tools used to study soil erosion [2]. Traditional examples are the placements of erosion pins or gerlach traps in order to monitor the changes by taking periodical field measurements [3]. Other field monitoring station can be sensors of ultrasonic technology to estimate the distance changes between soil surface and the sensor [4]. Cross section surveys and terrestrial laser scanners is another field alternative methodology to study soil erosion [5]. Field applications demand hard-working task and are time consuming in contrast to remote sensing application [6].

The specific study describes the development of the GIS Stream Bank Erosion Index. The stream bank erosion index was developed in a GIS environment by combining different parameters by using also satellite images to identify the hot spots of erosion. Such indices have been used worldwide [7]. Reseachers incorporated eight parameters such as rain erosivity, lithology, stream bank slope, Longitudinal River gradient, meander index, vegetation cover, soil erosivity and anthropogenic [8]. Other researchers also used eight parameters, i.e., rainfall erosivity, lithological factor, bank slope, meander index, river gradient, soil erosivity, vegetation cover, and anthropogenic impact [9]. In another study, four major factors: Topography (TWI), soil, land use and potential location of gullies were applied [10]. Additionally, others combined the slope, aspect, relative relief, slope length and steepness (LS) factor, curvature, landforms, topographic wetness index (TWI), stream power index (SPI), stream head density and land use/land cover [11].

The predisposing factors used in this work are: the soils, the landcover expressed via satellite imagery, topographical factors e.g., stream power index (SPI) and topographical wetness index (TWI), the rainfall erosivity index, a human-made constructions index (infrastructure) and finally the water yield index as generated by hydrologic modeling in m^3/s [12]. This index allows us to monitor hot spots in the stream and the banks at a large scale by using remote sensing techniques. Furthermore, it was validated by airborne-captured images using drones and additionally we have implemented a known field observation protocol, the Bank Erosion Hazard Index in order to verify the produced GIS-based results with field measurements in specific locations.

2 Methods or Materials

2.1 The pilot area

The Aggitis basin (Aggitis River is the main water path), located in North Greece, has a perimeter of 243 km and an area of 2389 km^2. The land cover of the pilot area is mainly occupied by agricultural lands, broad-leaved forests natural grasslands and sclerophyllous vegetation based on the sites recorded in 2018 land cover. The topographic datasets used in this study as primary data were the digital elevation model (DEM), the aspect map, the slope map, the curvature map in order to further develop the flow accumulation and flow direction maps that were used in other indices (Figure 1.a to Figure 1.d).

2.2 The rainfall erosivity index

The rainfall erosivity index was downloaded from the European Soil Data Center (ESDAC) of the Joint Research Centre of European Union. The ESDAC provides the EU map with complete rainfall erosivity dataset for the European Union (28 member States) and Switzerland based on high temporal resolution rainfall measurements of 26 years. This factor was calculated based on the Universal Soil Loss Equation (USLE) model, which is the most frequently used model for soil erosion risk estimation [13]. The rainfall index is depicted in Figure 1.e.

2.3 The stream power index

According to Wilson and Lorang (2000), The stream power index (SPI) is the measurement of erosive power associated with flowing water based on the assumption [14]. The formula that can be used to estimate the SPI (Figure 1.f) from primary datasets (digital elevation model, aspect, slope, and flow accumulation) is the following Equation 1 [15]:

SPI = LN(([Flow Accumulation] + 0.001) * ((Slope]/100) + 0.001)) Equation 2.1

2.4 The topographic wetness index

The topographic wetness index (TWI) was developed by [16] within the runoff model TOP-MODEL. The Topographic Wetness Index (TWI), the most commonly used hydrologically-based topographic index, describes the tendency of a cell to accumulate water; it is defined as follows:

$$TWI=\ln(SCA\tan\varphi) \qquad \text{Equation 2}$$

where SCA is the Specific Catchment Area and φ is the slope angle, assuming the properties of the soil as uniform [17]. High values of TWI represent the converging flat terrain while low values are typical at steep diverging areas. Figure 1.g represents the TWI for the pilot area.

2.5 The soil erodibility index

The soils of the basin are classified as (Figure 1.h): a) Calcaric Fluvisol, b) Calcaric Leptosol, c) Calcaric Regosol, d) Chromic Luvisol, e) Dystric Cambisol, f) Dystric Leptosol, g) Eutric Cambisol, h) Eutric Histosol, i) Eutric Leptosol and k) Vertic Cambisol. In order to quantify the specific factor, we used the soil erodibility factor USLE_K from the Universal Soil Loss Equation. The K-factor, which expresses the susceptibility of a soil to erode, is related to soil properties such as organic matter content, soil texture, soil structure and permeability. USLE_K was calculated by the Equation 3 presented by Sharpley and Williams (1990), where “ms”, “mc”, “msilt” and “orgC” are the percentages of sand, clay, silt and organic carbon, in the soil [18].

$$K=(0.2+0.3\cdot\exp[-0.256\cdot ms\cdot(1-msilt100)])\cdot(msiltmc+msilt)0.3\cdot(1-0.25\cdot orgCorgC+\exp[3.72-2.95\cdot orgC])\cdot(1-0.7\cdot(1-ms100)(1-ms100)+\exp[-5.51+22.9\cdot(1-ms100)]) \quad \text{Equation 3}$$

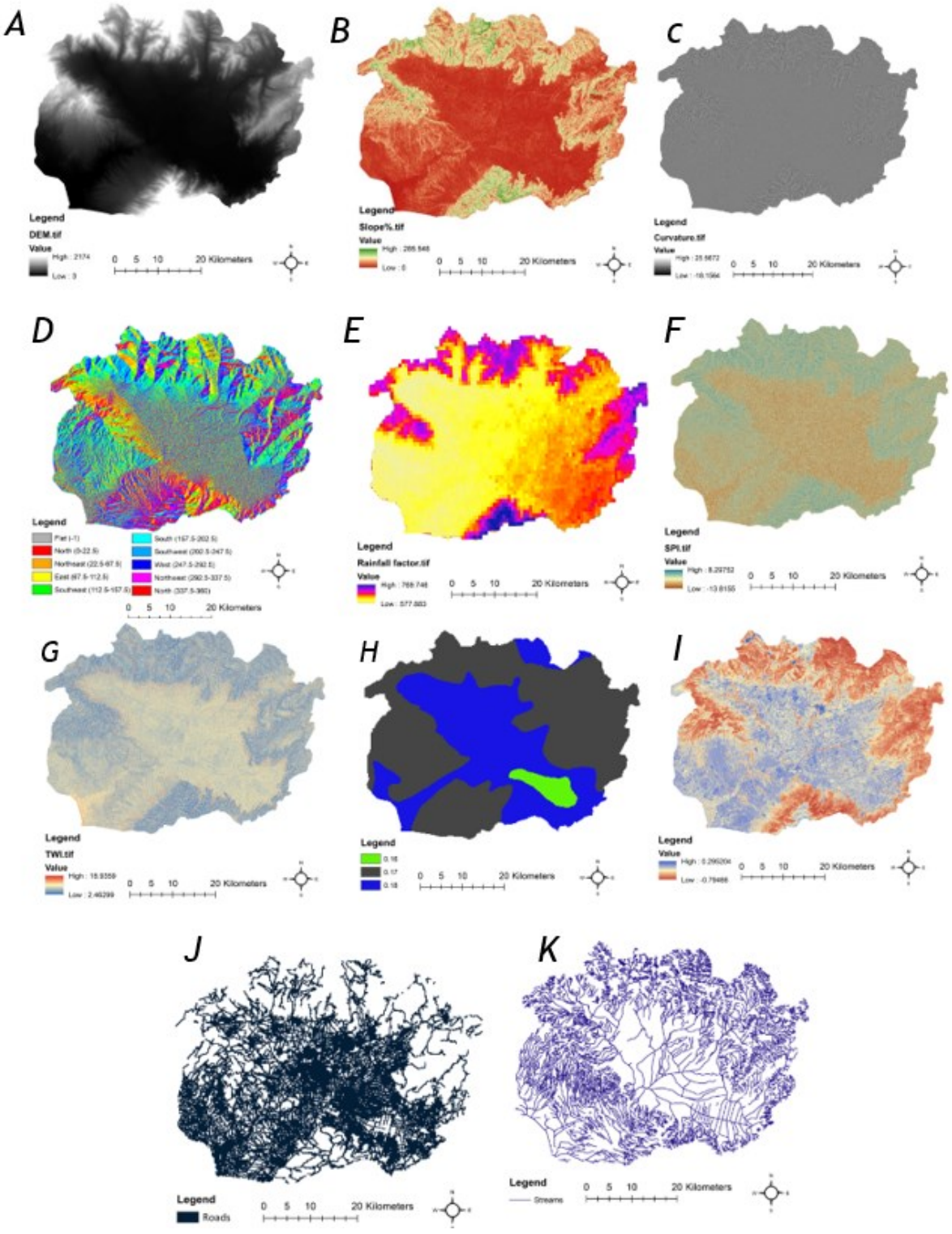

Figure 1. The a) DEM, b) slope (%), c) curvature, d) aspect, e) rainfall erosivity index, f) stream power index, g) topographic wetness index, h) soil erodibility index), i) normalized difference vegetation index, j) infrastructure index and k) water yield index for the Aggitis Basin.

2.6 The normalized difference vegetation index

The Normalized Difference Vegetation Index (NDVI) is a very popular proxy for vegetation cover and is worldwide applied in research on environmental and climatic change (Bhandari et al., 2012). NDVI is calculated based on the following equation [19]:

NDVI = (NIR – Red) / (NIR + Red) Equation 4

The NDVI is a dimensionless index that describes the difference between visible and near-infrared reflectance of vegetation cover [20]. The index value varies from -1 to +1. The higher the value is (close to +1) reflects high Near Infrared (NIR) which means dense greenery and healthy vegetation cover. Satellite images covering different time periods (from winter to late autumn images of 2019, 2020, 2021) were downloaded. Less than 5% of cloud cover was, among others, one of the important image quality criteria. The produced result (see Figure 1.i) depicts the NDVI index on a colorized scale from -1 (red) to +1 (green).

2.7 The infrastructure index

Furthermore, an important aspect that enhances the soil erosion or deposition location is the infrastructure. Man-made constructions such as roads, dams, bridges, etc. play a vital role, especially referring to streambank erosion. As for this pilot area, the road network was included as on/off parameter to develop the Infrastructure Index (Figure 1.j).

2.8 The water yield index

The specific index corresponds to the water yield in the stream network. This dataset corresponds to the water flow which can be found in the streams. This can be measured directly by field measurements or modelled via hydrologic models. The specific index was estimated by the Soil and Water Assessment Tool (another activity of the Protect-Streams-4-Sea Project) and the average simulated values of the streamflow (in cubic meters) where added in the main stream network of the Aggitis Basin produced by SWAT (Figure 1.k).

3 Results

In order to develop the GIS erosion index, we used the "Spatial Analysis Toolbox – Map Algebra – Raster Calculator" and combined the previous described indices. The specific procedure resulted to Figure 3 where the five classes (from very low to very high) represent the Stream Bank Erosion Index developed in GIS. This index allows us to monitor hot spots in the stream and the banks at a large scale by using remote sensing techniques.

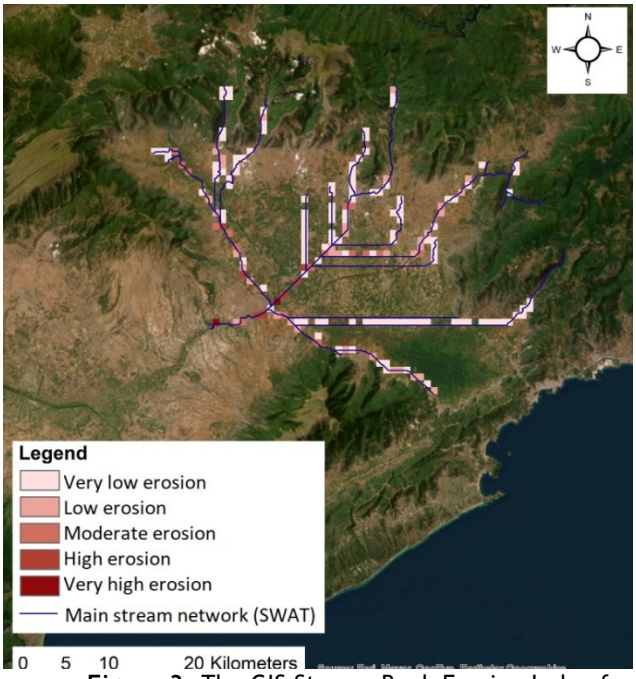

Figure 3. The GIS Stream Bank Erosion Index for the Aggitis Basin in the main SWAT's stream network. Five classes represent different rates of stream bank erosion: very low, low, moderate, high and very high.

4 Discussion

The produced GIS streambank erosion map was validated by a known field observation protocol, the Bank Erosion Hazard Index (BEHI) with field measurements in specific

locations. BEHI takes into consideration many physical phenomena (e.g., top of bank, bankfull height, rooting depth, root density, bank angle, percent bank protection, bank composition, bank material stratification) and scores stream banks categorically from very low to extreme bank erosion hazard [21,22]. We used 8 different channels to verify the results. The field measurements were made by systematic sampling: 100 meters between sampling locations. Generally, BEHI results showed a good agreement with the produced results of the GIS Stream Bank Erosion Index. We selected to showcase the verification sites of Monastiraki-Agia Varvara Stream and Kallifitos torrent.

The total length of the central Monastiraki-Agia Varvara stream is 2.53km, of which 381.53m is an underground cube-shaped culvert that passes through the street 19th May, one of the central streets of the city, and ends at the Park of Agia Varvara. In several sections, there are concrete structures that prevent the phenomenon of erosion in the stream. Another important observation is that the stream along its longest length is protected by the vegetation that has covered the slopes as well as the stream bed. Residents of the area reported that they had several erosion problems, however, after the creation of protection measures, the condition of the stream improved without causing any more problems in the city. However, there are still several points showing erosion; these points indicate that in extreme weather events big problems may be created, therefore these locations should be managed so that they do not extend to large sections.

The total of Kallifitos torrent length is 4.16km, of which 730m is an underground cube-shaped culvert that passes from the area of Anaplasi to the city of Drama. The measurements showed that there is a large percentage of streambank erosion, especially in the section before the Irish bridge at the east part of the city. This section, every year and especially in the winter/spring months, collects a lot of transported materials that come from the upstreams. Nevertheless the Irish bridge acts as a filter holding large amounts of transported materials and reducing the water velocity, so no problems are created in the rest of the stream (after the Irish Bridge). It is also important to mention that a large part of the stream is underground and flows through the city of Drama. The adoption of protection measures to prevent the deposition of large amounts of transported materials and at the same time this will reduce the water velocity resulting in the reduction of streambank erosion in the parts of the central stream.

5 Conclusions

Different factors such as the erodibility of soils, the landcover expressed via satellite imagery, topographical factors e.g., stream power index (SPI) and topographical wetness index (TWI), the rainfall erosivity index, the human-made constructions and finally the water yield (m^3/s) as generated by hydrologic modeling in order to develop a streambank erosion index in GIS. Furthermore, it was validated by implementing a known field observation protocol, the Bank Erosion Hazard Index in specific locations. This index allows us to monitor hot spots in the stream and the banks at a large scale by using remote sensing techniques.

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

High resolution photogrammetric products by unmanned aircraft systems (UAS) for post-disaster studies. Case study: a storm-tornado in Greece

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ABSTRACT

This article presents the implantation of geographic object-based image analysis method (GEOBIA) on a forested study in Greece. We focused on the post impacts of an extreme storm-tornado that hit Amfipolis, Nea Zicnhi and Pangaio Municipalities. Specifically, a flight of an unmanned aerial vehicle enabled the collection of high-resolution and accuracy images. These images developed the orthomosaic of the area and the GEOBIA analysis in Geographic Information Systems highlighted the impacts of the storm event at the tree trunks of the forested site.

Keywords: drone, image classification, orthomosaic, segmentation, feature detection,

1 Introduction

Unmanned aerial vehicles (UAVs) have been widely used over the last decade to collect data for forest research and there are many different applications for post-disaster studies and management of forested areas [1-6]. Image classification and automatically tracking of features via remote sensing or UAV-based has been widely used to study forests. Traditional pixel-based image classification (PBIA) assigns a land cover class per pixel [7]. In contrast, object-based image classification (OBIA) segments an image grouping small pixels together into vector objects [8]. The two basic principles of OBIA are: a) image segmentation in order to break the image up into objects representing land-based features and b) feature extraction and classification: to classify those objects using their shape, size, spatial and spectral properties [9]. Geographic Object-Based Image Analysis (GEOBIA) was proposed to distinguish from medical applications [10]. GEOBIA involves the processes of image-segmentation, attribution, classification, and the ability to query and link image-objects in space and time [11]. These methodologies have been used worldwide for landcover management and especially for agriculture purposes [12], for natural disasters (e.g., earthquakes, burnt areas, landslides, etc.) [13-15]. Concerning applications at forested sites, there are many studies for individual tree detection [16,17], for health classification or disturbances [18-20], for logging impacts [21,22], as well as for structural soil conservation measures, e.g., check dams, hillside terrace or stone terrace) [23,24].There many segmentation and classification techniques [25]. An example, is the “segment mean shift” tool in Geographic Information System (specifically in ArcGIS) that combined with the “image classification tool” (either supervised or unsupervised) can be used for object-based

image analysis [26]. The specific study implemented the above methodology in ArcGIS in order to study the post impacts on a forested site in Greece after an extreme storm event.

2 Materials and Methods

The study site is located at the main road connecting Amfipolis to Drama and is in the confluence with the road leading to Serres. The site is located between the villages of Palaiokomi and Nea Mesolakkia (Y: 40.866391, X: 23.869376 in WGS84). The UAV flight was programmed in November 16th 2022. The specific area was selected because it records very recent soil erosion phenomena that were not visible before. This happened due to a recent catastrophic event that broke the tree logs (pine trees) and flattered the area. The removal of the trees led to increased soil erosion that is visible in high rainfalls leading soil particles to the main road network. Generally, June 2022 was a rainy month for many parts of Greece, nearby stations recorded high rainfall amounts during this month: Eleftheroupoli (160.2 mm), Orfano (229 mm) and Nea Peramos (107 mm). A specific extreme event and a triggering factor was a hail storm with high wind velocities (a tornado was recorded) during the night of 25th June 2022. Wind velocity reached 92.5km/h (Beaufort Scale = 10) representing a "Whole Gale" with very high waves (≈9 m) with long overhanging crests in the sea while in land trees are uprooted and considerable structural damage is usually recorded. The strong wind caused extensive damage to warehouses and farm machinery; dozens of roofs were torn off, chimneys fell, while tables and chairs were carried away. Hailstorms destroyed all the grain that had not had time to be threshed. We had total destruction in corn, clover, cotton and sunflower seeds. The winds uprooted olive trees and almond trees, while the vines suffered great damage. Figure 2 represents different effects of the specific storm.

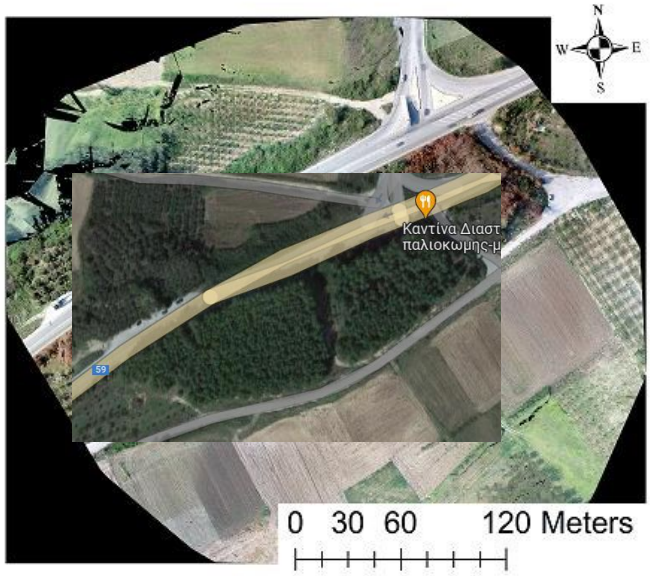

Figure 1. The forested study site.

3 Results and Discussion

Based on the orthomosaic, the PBIA application firstly led to image segmentation (Figure 3a), then image classification was done in ten different classes/colors (Figure 3b), followed by color/classes grouping in five categories (Figure 3c) and finally pointed out the fallen tree logs that also highlighted the direction (blue arrow) of the tornado from North-Northwest (NNW) to South-Southeast (SSE) (Figure 3d). Additionally, the presence of beehives was captured due to the removal of forest canopy (red circle). The method can capture the affected area, can estimate the number of fallen tree trunks, can highlight the incidence (wind direction) as well as other characteristics that may arise due to the absence of vegetation cover (e.g., soil erosion or other objects). In contrast, there were line segments (e.g., nearby the road alignment) that was also depicted in the results as well as other unnecessary natural characteristics (e.g., small brushes).

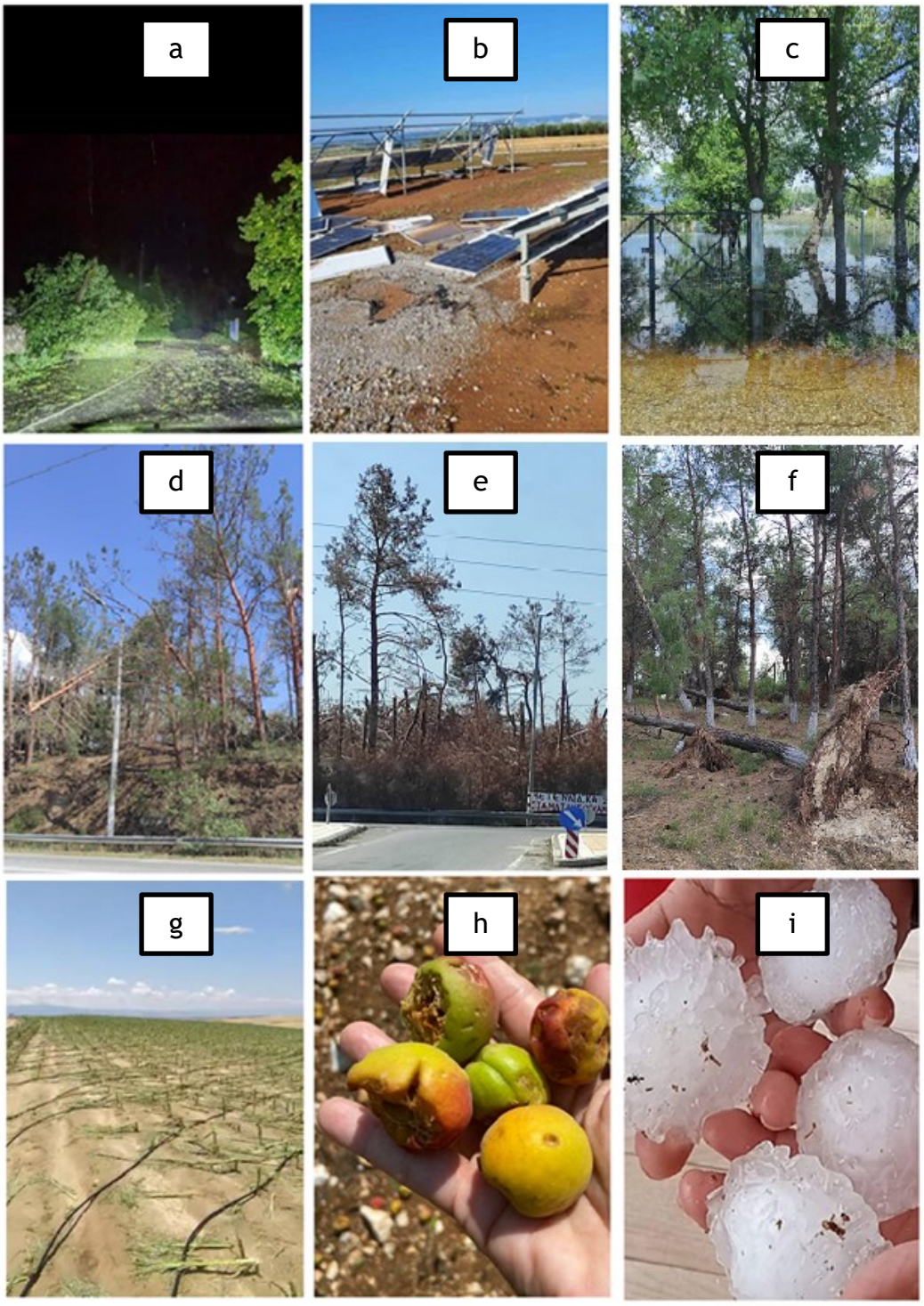

Figure 2. Photos of the hurricane's results in the greater area: (a) fallen leaves and broken trees covered the road, (b) disasters in constructions (solar panels), (c) flooded areas (land and buildings), (d) an aspect of the study location where trees destroyed (broken tree trunk), (e) an aspect of the study location after months where trees vanished, (f) different aspect of trees unrooted, (g) disaster in agriculture (sunflowers), (h) disaster in agriculture (fruit trees), (i) dimensions of hail,

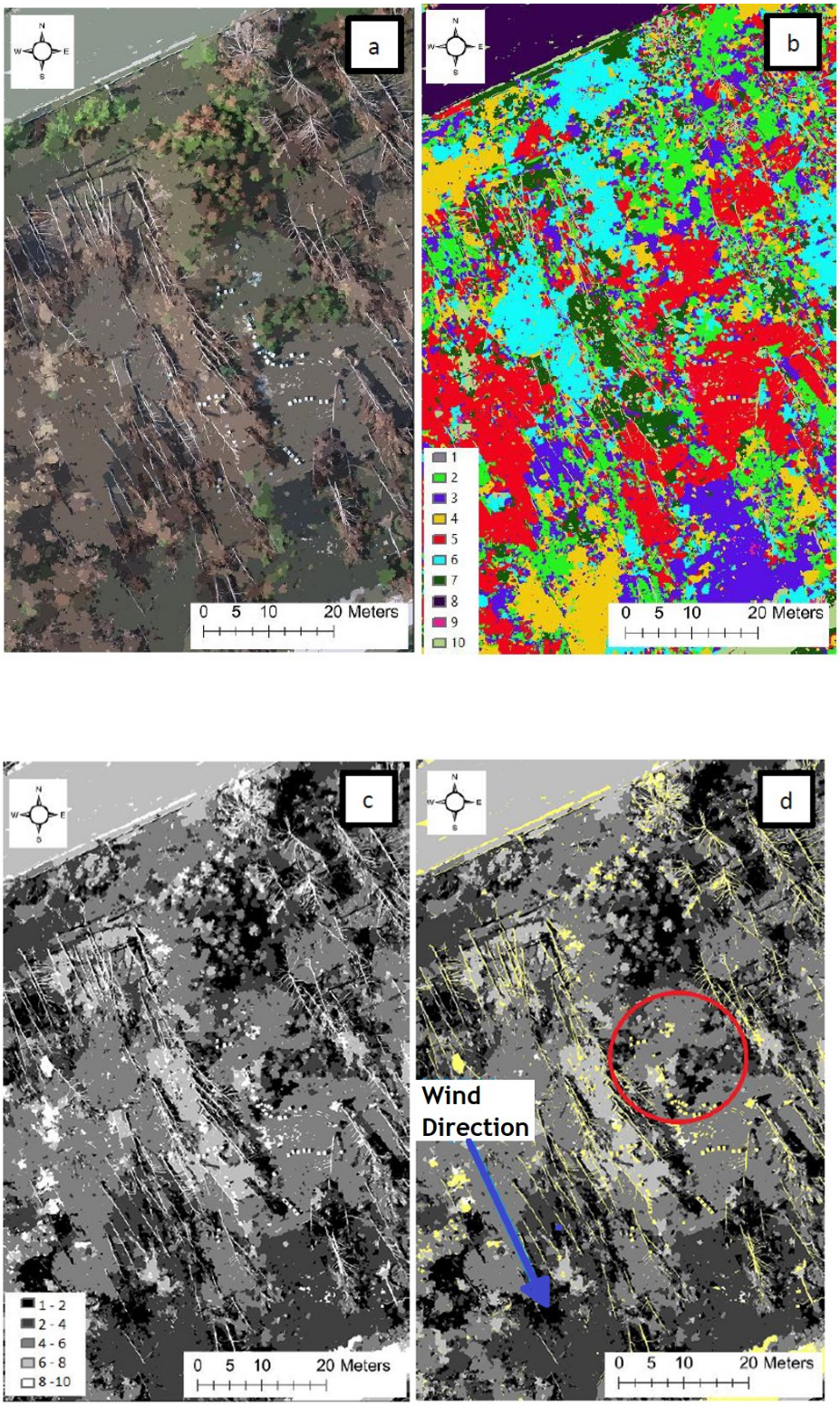

Figure 3. (a) The image segmentation based on the PBIA, (b) the image classification in different colors, (c) the color/classes grouping and (d) highlight the fallen tree logs, the direction of the tornado as from North-Northwest (NNW) South-Southeast (SSE) (blue arrow) and the existence of beehives was captured d to removal of forest canopy (red circle).

These results need to be excluded in order to calculate the final number of affected tree trunks. As mentioned above, the method is very optimistic in order to record the post-effects of such a storm in a forested area. The produced orthomosaic can provide high-detail spatial analysis. Furthermore, the OBIA method successfully delineated and classified the downed tree trunks objects. The majority of the classified downed pine trees follow a consistent linear pattern and cardinal direction from NNW to SSE showing the direction of the tornado that hit the forested area. The removal of the tree canopy allowed us recording the human presence with different activities (bees hives) and the conditions of the soil surface where soil erosion phenomena recorded due to the absence of vegetation. Such airborne methods may be the only alternative in inaccessible and dangerous areas especially during post natural disaster monitoring. Recently, ground-based and airborne lidar sensors have shown promising results of extracting forest stand structural parameters with high accuracy (e.g., diameter at breast height, stem count density, basal area and above-ground woody biomass) [27,28]. Coupling both ground-based and airborne will provide detailed mapping of forests and natural disaster management. In future studies, new information such as spatial autocorrelation and standard deviation that can be included into OBIA segmentation and classification decision rules will be examined to generate more accurate results. Additionally, ground-based photogrammetry should be incorporated for soil erosion monitoring.

4 Conclusions

The main conclusions drawn from this study are that downed tree trunks were successfully delineated using UAV-based data and an OBIA framework. This process can provide an easy and quick way to measure the affected area and the number of downed trees. In addition, you can extract information about the tornado conditions e.g., wind direction. Finally, the UAV-based data coupled with OBIA techniques can be implemented in cooperation to field-based methods for identifying and monitoring forested areas and especially post-disaster events.

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WEPP modeling of erosion and sediment in Moldova: Results for the Baltata River watershed.

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ABSTRACT

Soil erosion is one of the main factors affecting the soil fertility in the Republic of Moldova. The article presents the Water Erosion Prediction Project (WEPP) model for assessing soil erosion and sedimentation in the Baltata River watershed. Two alternative approaches of the WEPP modeling (Watershed Method, or offsite assessment, and Flowpath Method, or onsite assessment) were used to estimate the soil loss and sediment discharge for the 1991-2020 period. The model was utilized (a) for the entire Baltata River watershed and (b) for a smaller one, focused on the Recea River sub-watershed belonging to the Baltata watershed. The total modeled mean annual sediment yield in the Baltata watershed resulted in 5432 tones/year (or 0.4 t/ha/year); while the annual total value of soil loss was 21540 tones. The mean annual sediment yield in the Recea watershed was 43 tones and the annual total value of soil loss was 92 tones (0.1 to 0.3 t/ha/year). Thus, the study has showed that WEPP is indeed an effective tool for assessing soil erosion processes and sediment deposition in the catchment area of a relatively small river.

Keywords: soil erosion assessment, sedimentation, hot spots, river, watershed

1 Introduction

Soil erosion is considered as one of the most significant processes related to surface hydrology. Modeling of soil loss and sedimentation, along with field measurements, are a permanent challenge in natural resources and environmental planning [1]. In recent years, a number of conceptual hydrological simulation models have been developed and increasingly used by hydrologists and water resource managers to understand and address the extensive array of water resource problems, including those related to watersheds, streamflow and reservoir management, as well as to human activities that affect water systems [2]. The selection of the hydrological model depends on the research objectives, the availability of input data to its running and the uncertainty in interpreting the outputs obtained [3]. Small countries are objectively limited in hydrologic modeling capabilities due to the maintenance, computational costs and technical capacity that are needed to develop and run up-to-date modeling tools. In addition, the database of both weather data, discharge data or soil loadings, especially for small rivers, are scarce. This is partly why the hydrological modeling for simulation of hydrologic and flood dynamics on rivers of Moldova is very limited [4]. There are different models utilized in the territory of Moldova such as: HEC-HMS (Hydrologic Engineering Center - Hydrologic Modeling System) and HEC-RAS (Hydrologic Engineering Center - River Analysis System), JAMS/J2000 hydrological model, Soil and Water Assessment Tool (SWAT), rainfall erosivity model, Modified Fourier Index

(MFI), Universal Soil Loss Equation in Geographic Information Systems (GIS) [5-11]. In this study, the Water Erosion Prediction Project model (WEPP) was selected to estimate the erosion loss and sediment yield in the Baltata River watershed.

2 Materials and Methods

The Water Erosion Prediction Project model (WEPP) is a characteristic software that incorporates the soil erosion modules based on the hydrologic characteristics. WEPP is a complex process-based, distributed-parameter, continuous-simulation model for erosion prediction that incorporates the fundamentals of soil hydrologic and erosion science [12]. WEPP was developed by a pool of United States of America (U.S.A.) federal government scientists, university researchers, and action agency representatives from 1985 to 1995 [13]. It consolidates climate, soil infiltration, water balance, plant growth and residue decomposition to predict surface runoff, soil loss, deposition and sediment delivery over a range of timescales, including monthly and yearly totals or an average annual value based on data for several decades [14]. Generally, WEPP uses physically-based equations to describe hydrological and sediment generation, and transport processes at the hillslope and in-stream scales, implementing due its modeling procedure two fundamental tasks: runoff modeling and erosion/transport modeling [15]. Through the model's erosion components, all three stages of erosion (detachment, transport and deposition) are quantified, using the rill-inter-rill concept of describing sediment detachment. WEPP has a number of customized interfaces developed for common applications such as soil erosion, sediment yield and runoff. In the late 1990s, it was coupled with GIS software (GeoWEPP) and then its web-based model applications were developed [16]. The input information for the GeoWEPP simulation basically includes: a) the Watershed Topography as Digital Elevation Model (DEM), the soils, the land-use and local climate parameters.

The Baltata River is a small tributary of the Dniester River, being entirely located on the Moldova territory, in its central-eastern part. The 10×10m DEM was built on the digitized and vectorized 1:25,000 topographical maps of the area (see Figure 1). The main types of land-use in the Baltata watershed were recorded in the study area description based on the CORINE2018 database (see Figure 1). The Baltata watershed soils were extracted by vectorization of the available 1:50,000 soil maps and were classified according to the FAO's Global Soil Reference Database (see Figure 1). The climate information, needed for the GeoWEPP simulation was imputed in the model through the PRISM (Parameter-Regressions on Independent Slopes Model). This tool allows modifying the available climate files in order to more closely match a study area's climate. In our case, we used this information from the Baltata weather station for the 1991-2020 period and related it to a weather station located in the U.S.A.

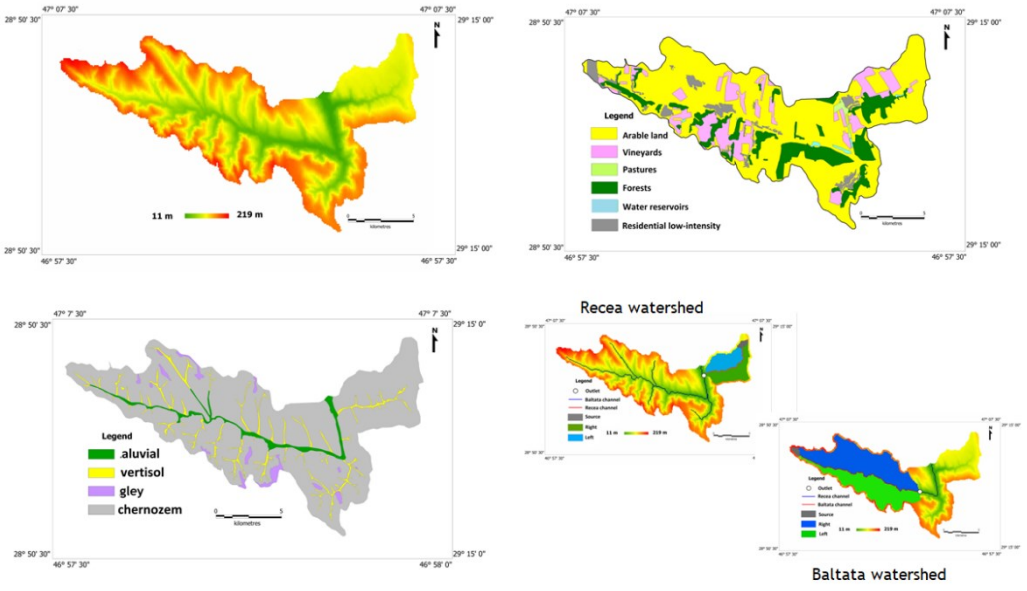

Figure 1. The a) DEM, b) the land-use. c) the soils and d) the two studied watersheds.

Concerning the erosion and sediment simulation, GeoWEPP provides two alternatives: a) the Watershed Method and b) the Flowpath Method [17]. The Watershed Method determines a representative profile and assigns one dominant soil and one dominant land-use for each hillslope in the sub-catchment. Therefore, this method is also called the offsite assessment. The Flowpath Method, also called the onsite assessment, concentrates on each flow path within the sub-catchment, and therefore the reported values refer to the amount of soil loss or deposition occurring in each raster cell of the sub-catchment. Thus, the watershed method reports which hillslopes are the problem areas in the study area, while the flowpath method shows which portions of a particular hill are the main contributors to this problem [18]. Both of these methods were employed: firstly, the model was tested in the Recea River watershed and at a second phase, it was utilized in the entire Baltata River watershed (see Figure 1).

3 Results and Discussion

The two approaches of GeoWEPP's implementation (offsite and onsite ones), differ in their outputs and thus complement each other. Therefore, their parallel use should be considered as an imperative. The offsite simulation, based on the watershed method, resulted mainly in sediment yield estimations after aggregating information for representative hillslopes. On the other hand, the onsite simulation, based on the flowpath method, estimated soil loss through aggregating the information of multiple WEPP hillslope runs. Depending on the spatial representation of flow paths, the results of the two approaches are different by definition; both are presented as maps in Figure 2 for the Recea watershed and Figures 3 and 4 for the Baltata watershed.

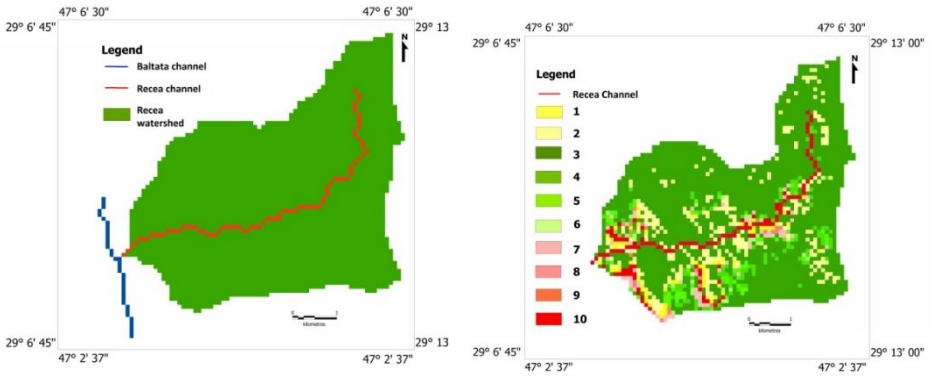

Figure 2. a) the offsite and b) onsite simulation of annual soil loss and sediment deposition in the Recea watershed for 1990-2010. The sediment deposition and soil loss (ton) is classified as: 1) <1.0; 2) <1.0; 3) 0 <= Loss < 1.4; 4) 1/4 <= Loss < 1/2, 5) 1/2 <= Loss < ¾; 6) 3/4 <= Loss < 1; 7) 1.0 <= Loss < 2.0; 8) 2.0 <= Loss < 3.0, 9) 3.0 <= Loss < 4.0 and 10) > 4 ton

In Moldova, according to a systematic survey of soil erosion, more than 36% of farmland is eroded in some degree [19]. The results are close enough with other modelled outputs based on the RUSLE method for a greater but similar study area (the Middle Prut Plain with an area of 2,316 km^2, which corresponds to the 6.8% of Moldova [20]. Similar to other studies [21-24], the highest erosion rates recorded at the razed pasture banks, while the grass area banks had approximately equal rates of erosion and deposition. The riparian forest buffer banks had also high erosion rates. The highly eroded slopes recorded, as expected, as ravines, gullies and landslides (0-5°). It should also be noted the simulated values of sediment delivery per unit area (0.4 t/ha/yr for the entire study area) are in the frame of the EU assessment, which has estimated the average rate of soil erosion of 0.2–3.2 t/ha/year on a per-country basis in Europe [25].

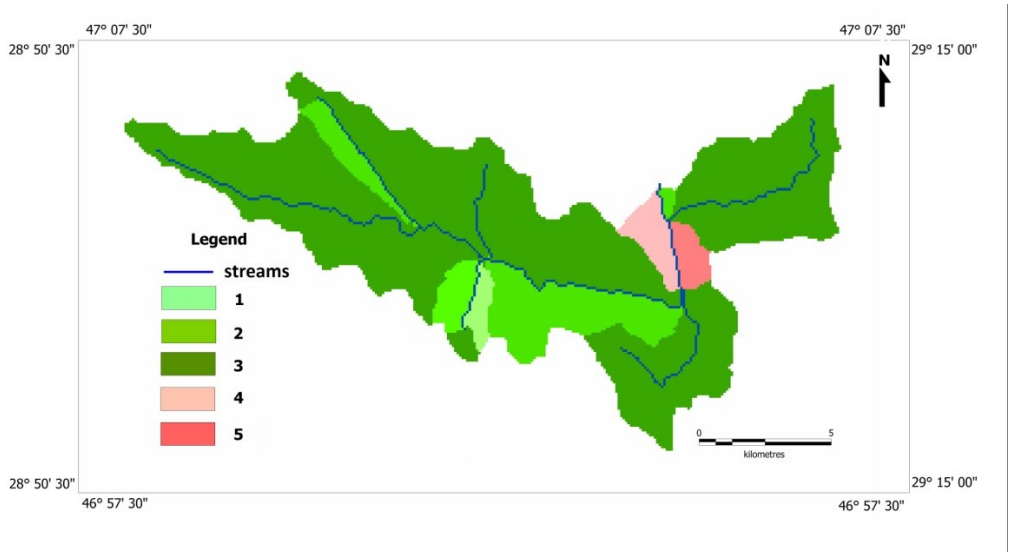

Figure 3. Map of GeoWEPP offsite simulation of annual sediments distribution in the Baltata River watershed for the period 1990-2010. The sediment yield (ton) is classified as: 1) 0 ≤ Yield < ¼; 2) 1/4 ≤ Yield < ½;3) 1/2 ≤ Yield < 1; 4) 1.0 ≤ Yield < 2.0; 5) 2.0 ≤ Yield < 3.0.

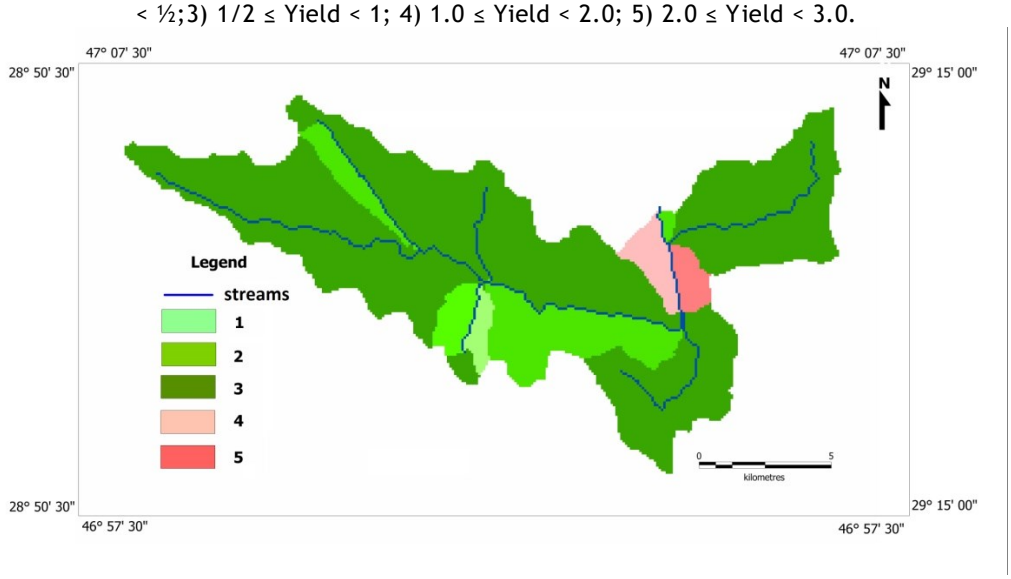

Figure 4. Map of the WEPP onsite simulation of annual soil loss and sediment deposition in the Baltata River basin in 1990-2010. The sediment deposition and soil loss are classified as (ton): 1) < 1.0; 2) < 1.0; 3) 0 ≤ Loss < 1.4; 4) 1/4 ≤ Loss < 1/2; 5) 1/2 ≤ Loss < 3/4; 6) 3/4 ≤ Loss < 1; 7) 1.0 ≤ Loss < 2.0; 8) 2.0 ≤ Loss < 3.0, 9) 3.0 ≤ Loss < 4.0 and 10) > 4 ton.

A slope is a very important factor for soil erosion; the left hillslope is affected the most by runoff and soil loss in both Recea and Baltata watersheds due to a steeper terrain at this side. Furthermore, traditional field monitoring of soil erosion has been performed to verify the accuracy of the modeling results. Recently (summer of 2022), erosion pins and erosion field plots have been installed in different places (hot-spots) of the study area in order to measure the deposition/erosion in different land-uses and soils. Specifically, in the area of Balabanesti (WGS84 Coordinates: N 47°04,1763' & E 29°07,3837') an erosion plot with dimensions 1.5m x 2m and with 20 erosion pins was installed in the stream bank of Baltata River in a slope of 40°. Initial results correspond to 0.2 m/year difference (in the erosion pin) or 0.6 m3/year of soil loss (at the specific erosion plot). As the area is dominated by Chernozems and the mean bulk density of this soils is equal to 1800 kg/m3 [26]; thus, the soil loss was equal to 1.08 ton/ha/year. The measurements have been done after major events (during Autumn and Winter of 2022) to record any changes and estimate the mean

values per year, and this overestimated the soil loss. Unfortunately, the last year 2022 was characterized by a long drought period with several extreme events which represented the average mm/year in a few days. Furthermore, the increased observed values may be resulted due to the great streambank slope. In flat slopes, where mainly sheet and rill erosion occurs, simulated and observed results may be similar. For this reason, field monitoring of the erosion pins is still in progress. Also, the sediments, created in this river catchment are accumulated and transported not only in the channel, but also deposited in the three reservoirs that exist in the area. Considering that 65% of the surface runoff accumulates here [27], it can be assumed the total volume of sediments and soils detachment, which can potentially enter the Dniester River, should be reduced by the indicated percentage. Furthermore, the climate change is expected to intensify the soil erosion processes and to impact the hydraulic structures and the hydrotechnical constructions behavior in the case of extreme hydro-meteorological phenomena [28].

4 Conclusions

The study has showed that GeoWEPP is an effective tool for assessing soil erosion processes and sediment deposition in the catchment area of a relatively small river. The model allows, based on the available climatic, topographic, soils, and land use/land cover data, to carry out different scenario simulations, while varying by the two methodic approaches and spatial resolution of the modeling procedures. Given the novelty of the GeoWEPP application in Moldova (initially tested in the Recea watershed and then focused on the entire Baltata River watershed), the preliminary results of the soil erosion and sediment deposition assessment have approved to be very helpful in identifying the hot-spots of erosion and recommending the best practices to mitigate the negative effects of sediment pollutants on the agricultural fields and hydrographic network. In order to maintain the infrastructure conditions and to sustain the water quality and quantity of Moldavian rivers it is important to monitor the hot-spots of soil erosion/deposition and also implement nature-based solutions whereas is available. Future research should also include further simulations of climate change scenarios.

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

Hydrologic and hydraulic assessment of the Kanara's torrent in Proti Serron, Greece

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ABSTRACT

The project explores dangers of floodplain through utilization of appropriate software which processes and visualizes the hydrologic, hydraulics and geographical information which is of great importance to man. In the present work the danger of floodplain exploration followed a methodology based mainly on the use of three (3) software. The software of ArcMap, of HEC-HMS which receives data from the mentioned software which attributed the hydrologic simulation and attitude of under exploration water catchment area and to the use of software simulation of open pipe flow through the software HEC-RAS. The above software was chosen among others, since they have the ability to cooperate each other through software of Geographical Information System, such as the ArcGIS, so that the prior processing of data to be achieved and finally the visualization of final produced results with the form of maps which will be friendly to user.

In short, the work involves the following structure and procedure levels such as:

- The collection and process of primary data – The digital ground model (DTM), the digital data of use ground (CORINE 2018), the type of ground and underground (DIGITAL MAPS), the maps of hydrological information and area's hydrographic network.
- The hydrologic simulation of under investigation catchment for the calculation of storms and of potential flood for four periods of reinstatement (T=50, 100, 1000years).
- The hydrologic simulation of flow along the under-investigation stream for the calculation of both line energy and of pressure head.
- The under investigation chosen area (Case study) is one sub-basin of Aggitis river (sub-basin of Strymonas river) and specifically of the broader area settlement of Proti Serron and of Paggaio Mountain (south of Aggitis river), with area of almost 14.73km^2.

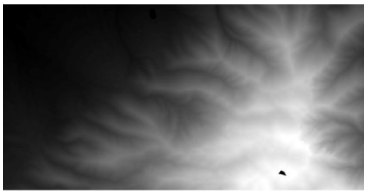
For the study area, because of lack of representative weather data and in general weather stations in sufficient time, even though data were collected after survey, and there are in the dissertation document, from the existing station for a time period of 15 years (2005-2021), an approximate calculation of hydrologic system conducted from standard rainfall IDF curve and specific acceptance. The primary goal of the present work was not only the accurate hydrologic study of the area, since there is not high density of weather stations, controlled and preserved in the long term, but also the exploration of floodplain areas in different floodplain incidents and the standardization of production methodology of floodplain maps. The conduction of hydrologic simulation of catchment was held with the calculation methodology of immediate runoff based on SCS, for the rain transformation into runoff based on SCS Curve Number (CN)

for the calculation of rain loss, with the aim of hydrologic simulation of stream “Kanara”. The results drawn through simulations were the calculation and depiction of floodplain areas for the most difficult hydrograph and for every reinstatement period. For the calculation of flood transit through streams of water, the Musking and Musking-Cunge methodology was chosen.

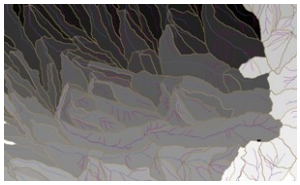
Keywords:ARCMAP, HEC-GEOHMS, HEC-RAS, catchment, simulation, water stream, Kanaras.

1 Introduction

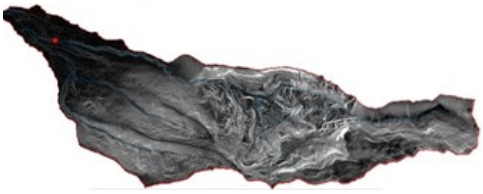
The softwares of ARCMAP, HEC-GEOHMS and HEC-RAS were chosen, since they have the ability to communicate and process Raster and Vector data set, as well as those of satellite images of Raster of Greek cadastre, 2007-2009 edition of spatial analysis 5m x 5m / pix (Picture 1) for the performance of Digital elevation Model (DEM). Next the satellite pictures processed through ARCMAP software (Terrain pre-prosecing) and of suite HEC-GEO HMS and illustrated the hydrographic network of the region and a couple of small catchments as following (picture 2). Due to the fact that our approach has to do with specific research area, merge of catchments conducted in an area of 14.73km^2.



Picture 1

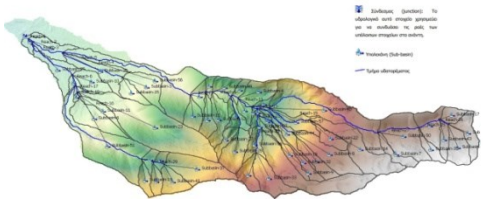


Picture 2



Picture 3

Next, the research focused on the analysis of hydrologic response of subbasin with the use HEC-HMS software initially the produced (DEM) was introduced and was created the BASIN MODEL COMPONENT and produced the hydrologic elements Subbasin, Reach, Junction Creation Tool which are presented in the following picture (Picture 4).The results of hydrologic subbasin after the process of the model,about acreage of individual subbasin the lengths and the slope of involved in research stream smaller stream.



Every water stream was considered that it has triangle cross section with the side slope equal to 1, whereas the coefficient speed based on Manning in the research has been taken equal to 0,06. In the present study only simulation of rainfall was held (Precipitation Method). The model HEC-HMS gives the choice of up to seven different rainfall methods. In the case study for all subbasin the method SCS Storm was chosen, which is a method of maintenance service of natural resources of USA and was developed to give information in terms of secure restoration facilities of water for agricultural applications. From the data process through rainy curves the following results of auspicious scenarios for reset periods T=50, T=100 και T=1000years as in the following Table 1.

SUBBASIN	T=50years	T=100years	T=1000years
RESEARCH AREA KANARA STREAM 14.73	110.72mm	123.23mm	171.19mm

(Table 1)

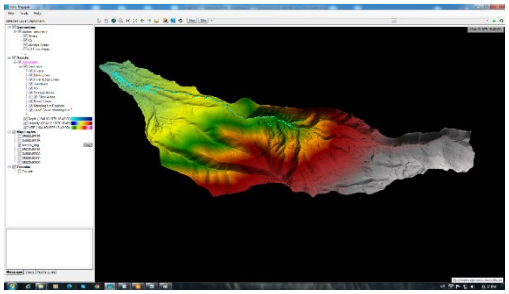
The next step of the project was the estimation of Unitary Hydrography of direct run off coming from clear rainfall lasting t_R and unitary height in uniformity delivered on the whole basin extent $(h_R = 1cm)$ The Soil Conservation Service of USA (SCS) developed one dimensionless unitary hydrography where the supply is expressed as the cause of supply as to peak qp, and the time, as the cause of time as to time growth of unitary hydrography Tp.
Next, the deceleration and delay time t_L was estimated. As it has already been presented , the rate resulting from the estimation of assembly time t_c . In the present project Giandotti type was chosen for the delay time (t_L) through

$$t_c = \frac{4\sqrt{A} + 1.5L}{0.8\sqrt{\Delta H}}$$

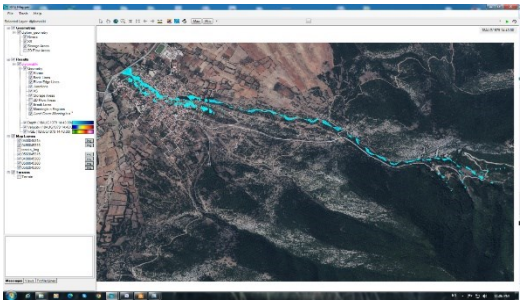
Also, the estimation of rainfall lack conducted, a difficult problem, since it depends on various factors such as the hydrologic basin and the rainfall elements. SCS uses the number of runoff curve CN (Curve Number), in which some of hydrologic features of basin are involved, such as geomorphology, lithology and vegetation, and it is defined with the help of tables of escalation 0<CN<100). The above were estimated through estimations in ARCMAP after digitations of geological map of the region and the data use of CORINE 2018 for the calculation of CN and it was found to have price equal to 70.

Next, the estimation of hydrological flow elements were noted (flood passage – of space-time development of a flood through a superficial aquifer) in HEC HMS through a series of models such as – models Lag, Muskingum, Modified Puls, Kinetic Wave, Muskingum Cunge. The above models estimate a hydrograph for the downstream of survey area, since initially a hydrograph is introduced for the upstream of the area as boundary condition. To come true, continuity and potential equations should be solved. In the present project, the choice of Muskingum – Cunge and not Muskingum model was chosen, since the second even if it is easy and widely known, it involves parameters which do not have a natural meaning and it is difficult to be estimated. Moreover, the Muskingum model based on conditions which often are broken in natural canals in comparison with Muskigum-Cunge model which has the quality to overcome such restrictions.

Finally, from the estimations through a rainfall scenario with 171.19mm in 12 hours time and after we introduce all those meteorological data which interest us through HMS menu and especially of sub-menu Simulation Run took place the simulation of model with final result the stage of peak flood 1.90m3/m. The same simulation took place for the other two rainfall scenarios with the performance 1.00m3/m. After the estimation of geomorphologic, hydrographic and hydrological data of the study area, next through the completed software HEC – RAS (Hydrologic Engineer Center- River Analysis System) which developed as the hydrologic software HEC – HMS from the mechanic department of American army the simulation of One-Dimensional flow was conducted. (one – dimensional unsteady flow). The above software involves plethora of functions such as the estimation ability of hydraulic jumps, hydraulic conditions in bridges, roof racks, sewers, overflowing (with or without portholes), strictures as well as the bed erosion in bridges even simulation of rift creation in barrier. Necessary elements for the simulation through the specific program is the engraving of geometric elements of survey area, the definition of main stream and the contributors to it streams with the indication of main river and tributary and finally the geometrical elements are completed, after the lower limit of study area is defined lower BC introducing of course the meteorological data, drawn from HEC HMS so as the unitary hydrograph to be created.
The final produced diagram in the present project is completed as the deluge map with the following form which depicts the Settlement of Proti Serron of Amphipolis Municipality of Regional Unity Serron, with the delude areas in the specific subbasin and with the given rainfall episode (1o Scenario) as in the following pictures (Picture 5 and 6).



Picture 5



Picture 6

2 Methods and Materials

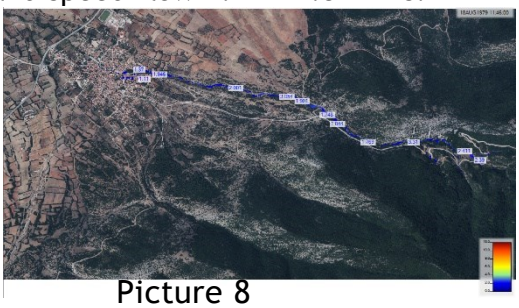
The used methods are involved in the scientific field of Geographic Information (GIS) and the hydrology and hydraulic sciences with the software use of ARCMAP, HEC-GEOHMS and HEC-RAS αλλά and of hydrological models. They supply a complete result of flood phenomena exploration and the simulation of floodplain areas through the process of satellite data but also earthly calculations both geographical and hydrological. Necessary elements, as it has already reported, are the collection of reliable RASTER and Vector data set and the plethora hydrological calculations from reliable rain gauge station.

3 Hydrological Results

The results of hydrological simulations depend on the quality of entry data to a great extend. Initially, the analysis of Dem plays an important role since a rough DEM can't depict accurately the geometry of water stream and possibly it will lead to false conclusions. Also, the power coefficient of soil (coefficient Manning) influences the results to a great extend. In bibliography there are various references for these prices but they present important fluctuations.

Based on results with the method of Specific Unitary Hydrography from the User through the method of contemporaneous curves for the user of maximum depth results for the subbasin research area, depth average 0.823 m which reaches in some positions 1.742 m. Concerning the map of maximum speed is estimated that the average speed flow is 2.07 m/s and in some areas 3.31 m/s. From the above, it is noted that areas of urban network flood with flow depth in span of 0.12 – 0.16 m and speed flow 1.11 – 1.37 m/s.

Picture 7



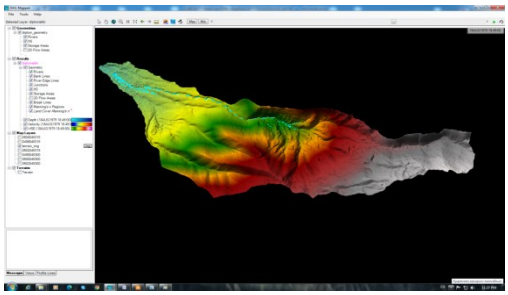
Picture 8

3.1 Land Use Results

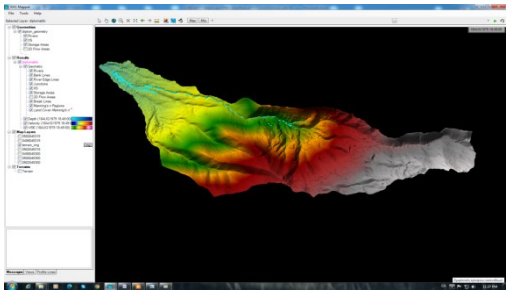
Applying the above methodology in the study area the following general conclusions emerge:
- The reliability of results based on the above methodology related to the number and the accurate available data as well as the regulation of some parameters. Important role plays also the appropriate price choice which belongs to price range.

The uses of Earth play crucial role in the produced results. They constitute a parameter of both the hydrological absences and produced coefficient price of Manning in the stage of hydrological simulation. Consequently, it is noted that the uses of Earth plays a crucial role

in different stages of methodology together with the great importance of the quality and accuracy of these data.
- The results of hydrological simulation depend to a great extend on the quality of entry data. Initially, the DEM analysis plays an important role, as a rugged DEM cannot depict in accuracy the geometry of water stream and perhaps it will lead to false conclusions. The ground speed (coefficient Manning) affects to a great extend the results of hydrologic simulation.
DEM - Raster Data Set Results
In the present survey DEM elements were noted in the focused subbasin runoff of "Kanara" stream and specifically from the start area sewer boxwoods to upstream and to the length 300m where the vegetation and tree cover of stream and especially the survey area is intense (Pictures 9 and 10).



Picture 9



Picture 10

We notice that DEM because of tall trees and dense vegetation in the water stream has been risen in association with the rest altitude and it has caused blockage in the water flow and as a consequence the furthern exploration of hydrological simulation in this position and in the specific department of under survey water stream to be impossible through satellite images. However, it can not prevent us from having a wide picture and approach as to produce map of flood deluge of regions in the urban net and for the part which runs the stream and involving fields. For the control, analysis and prove of failure DEM in the specific part, we proceed to topographic impressions of the existing condition of stream with the use of Geodesic GPS GNSS RTK and Geodesic Station-Total Station for the creation of landscape photography, Cross Section and Longitudinal and the results were compared.

4 Discussion

Questions can be arisen are many, such as how reliable these results are, the speed with which results are drawn and the cost of production. Also, how user friendly the software is. The answer in all these questions only positive connotation can have, since the exploration of an area is conducted only by one user or of few scientific members, also with open source data depend on the survey, with low cost and in short time depending again on the experience of the user.

5. Conclusions

The analysis and process of satellite images and hydrologic data through appropriate software can give in a short time results that can be used in the prevention of flood in urban areas, aiming to protect the human life and property. With the above methodology we can assess areas and classify them in relation to the rate of their vulnerability. During the use of software, positive and negative attitudes were noticed such as the software, ARC MAP which were useful and basic informational tool in the pre processing phase mainly of soil digital model and of performance of subbasin runoff, but it appeared problems mainly both in the transition of DEM to HEC-RAS and during the conveyance of hydrologic simulation results in Arc Map for the composition of flood maps. Also, the software HEC HMS even if it

is easy and reliable – user friendly, it has as a negative point the misguidance in case of mistake or problems in terms of estimations, which are partly solved with the presence of false messages. Also, it was noted that the menu process of results is complicated enough, if we take into consideration the experience of user with the software. Finally, HEC – RAS is considered to be the most important tool for the one-dimension analysis and simulation of the flow of water stream, which has the potential of water level estimation for gradually changing flow in water stream systems under subcritical and supercritical conditions. For the better assessment and research of the object, the survey is suggested to be applied with analysis and use of MYΓ not only according to SCS but also according to Clark and Snyder for the same restore periods under conditions of non permanent flow (there is the possibility for permanent flow) and the produced results to be compared and analyzed each other and in relation to the rational method.

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SESSION VIII “PS4S”-“Soil Erosion and Water Degradation”

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

Evaluation of provisional areas by residents of small urban areas with the use of photo questionnaires

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Abstract

Riparian areas provide many ecosystem services important to humans. The purpose of this specific research was to evaluate the perceptions of residents of small urban areas about coastal areas using a photographic questionnaire. We focused on the Municipal Unit of Kalambaki which is under the Municipality of Doxatos of the Prefecture of Drama in Greece. For the research, two slightly different questionnaires were used for the two categories of respondents who were ordinary citizens and professionals related to the management of natural resources. The questionnaires consist of three sections which are: 1) personal information, 2) different series of photos (with four photos) to rank their preference based on their personal assessment and finally 3) some general questions about coastal areas.

Keywords: streams, citizens, natural resource management professionals, anthropogenic impacts

1 Introduction

In every river there is a riparian zone, a complex and sensitive transition zone that connects the aquatic to the terrestrial environment (Walsh et al. 2005). The riparian zone in which riparian forest often grows is in dynamic equilibrium with the river, which changes it with its floods, but is also radically affected by it (Zaimes et al. 2010). Of course, this relationship is also influenced by man, who for hundreds of years has played a decisive role in the history of the waters of the landscape. The river carries water from a catchment to the sea and can be thought of as a vein draining an entire land area. Beyond this basic function, rivers and riparian zones are characterized by extremely high biodiversity both in flora and fauna (Pennington et al. 2010).

A river is closely associated with groundwater because its bed is at the lowest point in the landscape and is usually in contact with the groundwater aquifer (Petts and Amoros 1996). A flooded river supplies water to the underground aquifer, while receiving water from it during periods of water scarcity (Schultz et al. 2000). Riparian forest is forest vegetation that significantly affects a river and is significantly affected by it. Unlike a typical terrestrial forest, it contains mainly hygrophilous and moisture- and flood-tolerant species, since they

have to deal with a waterlogged soil and a strong and variable river flow (Schultz et al. 2000). The riparian forest is part of the riparian zone and together with the river forms a "river corridor" (Zaimes et al. 2011). The differences in riparian vegetation between a river and a wetland reflect the special characteristics of the river: the strong current of the water and the seasonal succession of floods and droughts (Furniss 1992).

In a river, our attention is mainly drawn to fish and birds. But these would not exist without the leaves that fall from riparian trees and invertebrates, just as the hygrophilous trees would not exist without the water and floods that make the soil fertile or nourish their deep roots during summer drought (Ζόγγαρης κ.α. 2007). The conditions and biocommunities that develop in riparian zones are a unique combination of influences from both aquatic and terrestrial environments (Zaimes and Iakovoglou 2021). Riparian trees live off groundwater, so they develop roots near the water table rather than throughout the soil profile (Zaimes 2020). Seedlings of some riparian species expend the precious reserves contained in their seed to develop a very long taproot during the first few weeks of life, delaying the development of the first leaves (Furniss et al. 1992). Mountain riparian forests renew 30-90% of their rhizomes every year – the tiny roots with which they absorb water and nutrients.

For the integrated management of water resources, the active participation of all stakeholders is necessary (Biswas 2008). Their first participation step is through a questionnaire. The purpose of the research was to determine the opinion/knowledge of residents of small urban areas and professionals about coastal areas using a simple and photographic questionnaire. The information of the answers to the questionnaire will inform us about the preferences and knowledge of the people about the riparian areas and will contribute to their more correct management. For the sustainable management of coastal areas, it is necessary to have proper information for both professionals and citizens (Zaimes and Iakovoglou 2021). Of particular interest is urban riparian stakeholders (Sukopp et al. 1995). Urban coastal areas have not been particularly studied in Greece.

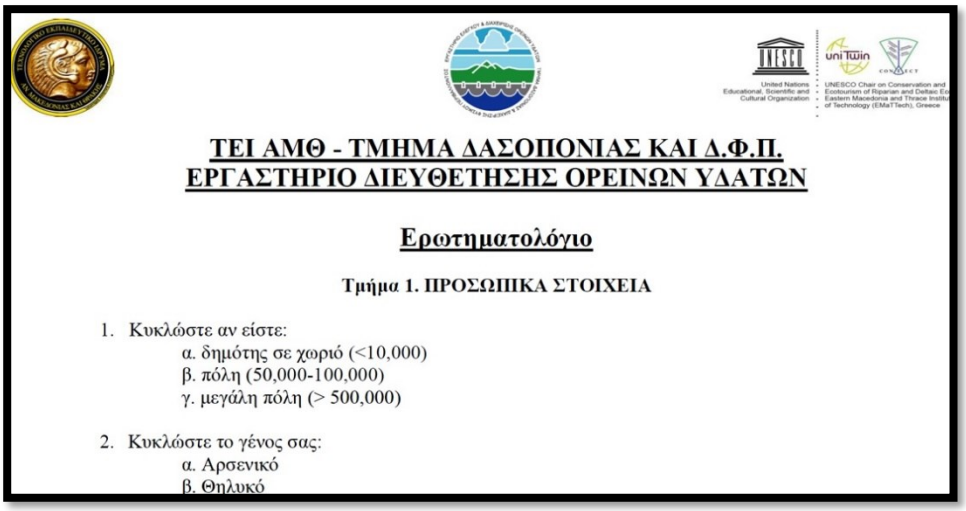
2 Materials and Methods

2.1 Study Area

The study area is Kalampaki, a lowland town in the prefecture of Drama with an altitude of 60 meters, and the surrounding villages. It is located 13 km south of Drama, the capital of the prefecture. The data were collected by completing the questionnaire from people who lived in Ftelia, Agia Paraskevi, Kalampaki, Kalamonas and Mikrochori.

2.2 Methodology

In the context of the research, the objective was to assess the knowledge about the importance and management of coastal areas, residents of small urban areas using a simple and photographic questionnaire. Respondents were natural resource management professionals working either in public organizations or private businesses and citizens. The questionnaire consists of three sections. The questions were closed-ended, except for one that was open-ended (Zaimes et al. 2020). The first section consists of six questions for citizens and nine for professionals concerning personal information (Figure 1). The second section consists of an eleven series of photographs of riparian areas that were ranked (Figure 2) (Kenwick et al. 2009). In each set of pictures there were four pictures and the participants chose which one they liked the most. The third section includes thirteen questions about riparian areas. The research was carried out for citizens with random sampling over a period of one month, every day from 09:00 to 14:00 on a main street of the study areas and for professionals with a visit to their workplace. After completing all the questionnaires, the data were transferred to excel and the corresponding diagrams were created. In case of non-response, the excel cell was not filled.



ΤΕΙ ΑΜΘ - ΤΜΗΜΑ ΔΑΣΟΠΟΝΙΑΣ ΚΑΙ Δ.Φ.Π.
ΕΡΓΑΣΤΗΡΙΟ ΔΙΕΥΘΕΤΗΣΗΣ ΟΡΕΙΝΩΝ ΥΔΑΤΩΝ

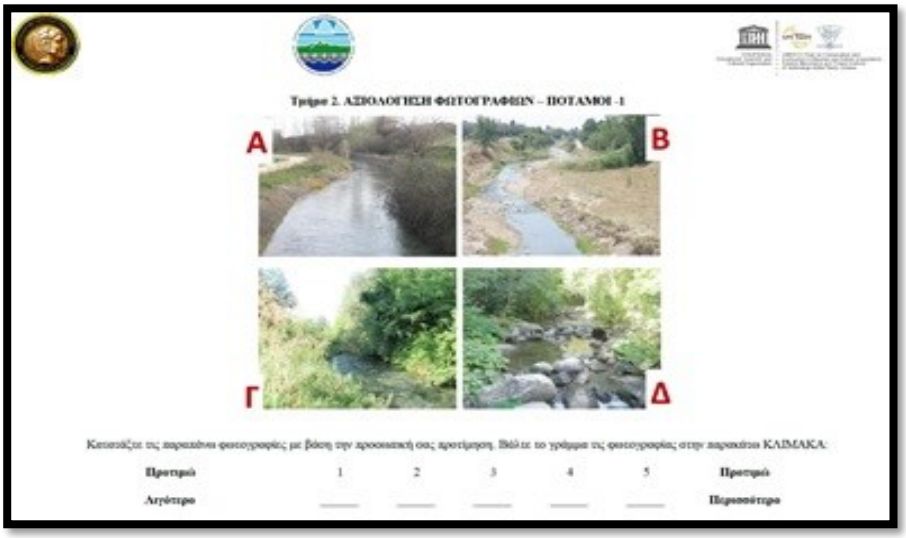
Ερωτηματολόγιο

Τμήμα 1. ΠΡΟΣΩΠΙΚΑ ΣΤΟΙΧΕΙΑ

1. Κυκλώστε αν είστε:
   α. δημότης σε χωριό (<10,000)
   β. πόλη (50,000-100,000)
   γ. μεγάλη πόλη (> 500,000)

2. Κυκλώστε το γένος σας:
   α. Αρσενικό
   β. Θηλυκό

Picture 1: The first two questions of the questionnaire for the first section.



Picture 2: Visual ranking of four photographs of different streams and torrents.

3 Results

The questionnaire consists of 3 sections: 1) personal information, 2) visual photo ranking, and 3) general questions about coastal areas.

3.1 First Section of questionnaire

In the first section of the questionnaire about personal information, three of the nine questions in total are presented. According to the results, the questionnaires were completed by 100 non-specialized citizens and by 30 professionals (Figure 1). In Figure 2 and 3 the results are presented with the aggregated responses (of professionals and citizens). At the level of education (Figure 3) we see that more than 80% who participated in the questionnaire had at least a higher education degree (ATEI or HEI). Finally, in the age groups (Figure 4) the largest percentages were 18-25 (29%) and 36-45 (28%).

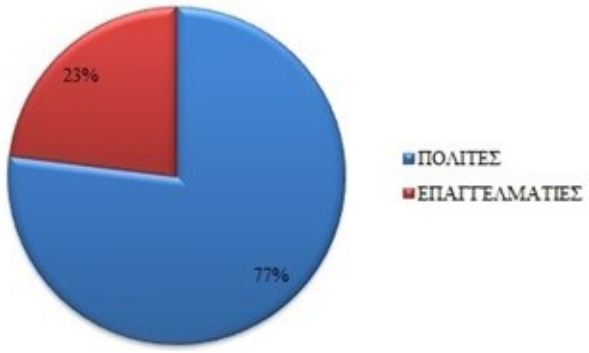


Figure 1: The percentage of professionals and the general public that participated in this research.

Figure 2: The percentage of the educational background of the research participants.

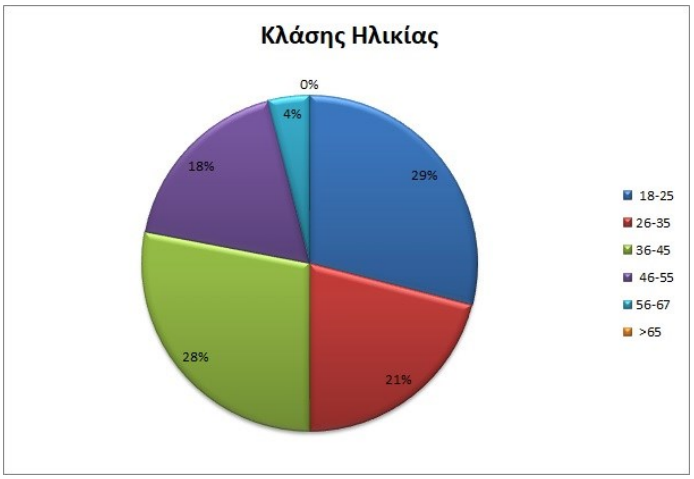


Figure 3: The percentage of the age groups of the research participants.

3.2 Second Section of questionnaire

In the second section of the questionnaire, for the ranking of the photos of the coastal areas, we had a total of eleven questions, of which three are presented with the aggregated answers (of professionals and citizens). Specifically in Figure 4 we see that the highest percentages appear in photos A, B, C with 27%, 26% and 26%, respectively. Therefore, this refers to riparian areas that have the presence of water and prominent vegetation.

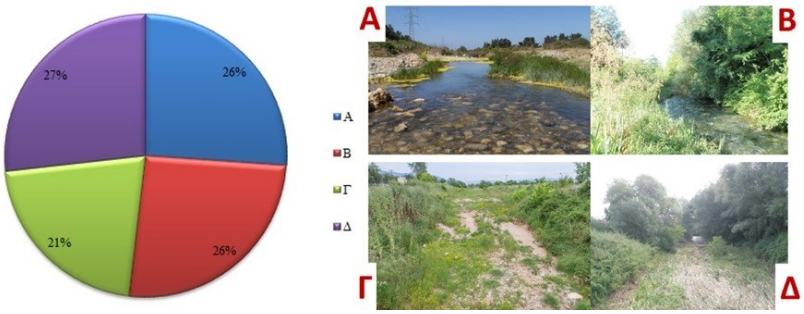


Figure 4: Photo Set 1. The percentage of each photo according to the preference of the participants.

In Figure 5 we also see the preferences of the respondents leaning towards riparian areas with slopes that maintain their natural condition. In particular, the highest percentages appeared in the A, D and B photo of the coastal area with 27%, 27% and 25%, respectively. In contrast, the smaller percentage preferred the coastal area where the slopes had strong human construction intervention (21%).

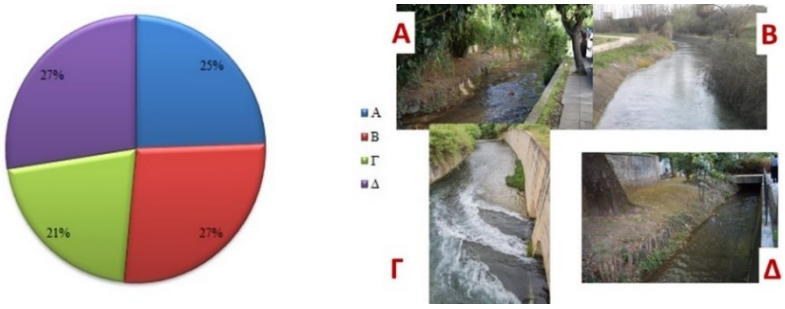


Figure 5: Photo Set 2. The percentage of each photo according to the preference of the participants.

In Figure 6 all the photos had almost the same percentages. This was expected because they have natural vegetation on the slopes. Of course, we expected D to have the smallest percentage because the waters have a lot of transported materials (dark brown color) and are aligned.

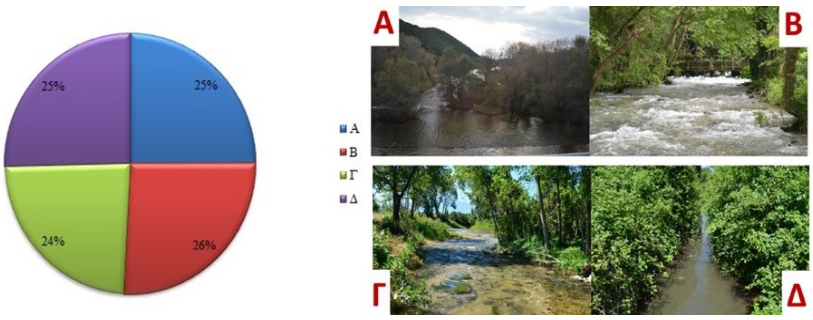


Figure 6: Photo Set 3. The percentage of each photo according to the preference of the participants.

3.3 Third Section of questionnaire

In the third section of the questionnaire there are a total of thirteen questions about coastal areas and the results from the two are presented with the aggregated answers (of professionals and citizens). Specifically, when asked if they prefer their house to be next to a river/stream with natural vegetation, the majority answered that they do not prefer it with 50% (43% disagree and 7% strongly disagree) (Figure 7). 20% of respondents had a neutral opinion and 30% would like their home to be located in a riparian area with vegetation (26% agree and 4% strongly agree).

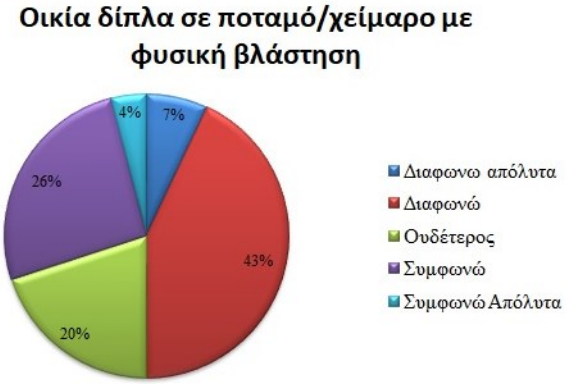


Figure 7: *The percentage of the people that would prefer their house near a riparian area.*

In Figure 8 we see the percentage of responses to whether "Should the local government enforce the preservation of natural vegetation in rivers/streams of residential areas". The majority with 55% (40% agree and 15% strongly agree) thinks it should. 33% answered that they are neutral and 12% that they disagree.

Figure 8: The percentages in regard to the whether the local authorities should enforce rules to protect the natural vegetation of urban riparian areas.

4 Discussion-Conclusions

The percentages of the results show that there is a difference of opinion among the respondents. This means that in order to create sustainable riparian management plans there must be active participation and cooperation of all stakeholders (Zaimes 2020). In the first section of the questionnaire, personal information was filled in for each person who participated in the survey. As expected the number of civilians was much higher than the professionals. Also, most of the respondents had at least a tertiary degree and there is a good spread between the ages of the respondents except for those over 56 years old.

In the second part of the questionnaire, the classification of various categories of coastal areas was carried out by comparing series of (four) photographs. In the first series of photographs (Figure 4) we expected respondents to prefer riparian areas with permanent water flow and dense vegetation. The two photos (A, B) had the above characteristics, but a significant percentage preferred streams without permanent water flow. This may be due to the fact that in Greece and the Mediterranean a large number of streams have periodic or temporary flow (Zaimes et al., 2010) and citizens are accustomed to such streams. In the second series of photographs (Figure 5) most respondents preferred streams and riparian areas with few anthropogenic impacts (A, B, D) (Kenwick et al. 2009). Of course, a significant percentage (21%) preferred the stream with parallel walls (C), something unexpected. In the last series of photos (Figure 6) all photos had approximately the same percentages. We expected photo D, because the stream is aligned and the waters have a lot of transported material, to have a much lower percentage.

In the third section there were general questions that were filled in by the respondents. The largest percentage did not want their houses to be double on a stream and in riparian areas (50%). In other developed countries the preferences are usually the opposite (Kenwick et al. 2009). Of course in Greece, people might be worried because of the sudden floods that regularly occur in streams, especially in urban environments (Zaimes 2020). Finally, it is positive that most people believe that the local government should enforce the good condition of the natural vegetation in the residential areas where they are close to the coastal areas.

Based on the above results, we believe that measures should be taken for the proper management, protection and arrangement of streams and riparian areas, which will lead to their further prominence and quality upgrade. Specifically, the following actions are recommended:

1. Informing and raising awareness of the citizens by the Forestry Department, the Forestry Directorate or the Municipalities through seminars that will include information on the importance of coastal areas and what their protection measures should be.
2. Approval of programs aimed at recording the supply of water in the various streams in order to solve the problems of the coastal areas due to reduced supply.

3. Approval of programs aimed at recording the state of the coastal areas so that they can be upgraded and become an ecotourism hub.
4. Taking action on potential contamination and pollutant problems for urban streams.
5. Avoiding human impacts such as grazing to ensure the stability and viability of riparian areas so they can provide their ecosystem services such as filtering and improving water quality and increasing biodiversity by providing habitats for wildlife.

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

Research studies on surficial and stream bank erosion in Siriu Reservoir and Buzau River – Chirlesti and Paltineni areas

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ABSTRACT

Pollution of rivers and seas is one of the most important issues of environmental protection along with the effects of global climate change. Ecosystems are affected, as well as human health. Two of the sources of surface water pollution are represented by the surficial erosion and the stream bank erosion considered nonpoint sources of pollutants that cause eutrophication especially in the closed seas such as Black Sea. To solve this environmental problem, the research is to identify and quantify the major sources of erosion, litter and pollutants using traditional methods such as alluvial traps and pins at the plot scale. In addition, NDVI and NDWI indices are applied in a GIS environment via satellite images in order to locate the most vulnerable areas on erosion. These activities will allow decision makers to select and to implement the best management practices and measures to reduce the pollution of the Black Sea and its tributaries.

Keywords: erosion, alluvial trap, pins, indices, decision makers

1 Introduction

The watersheds that end in the Black Sea provide many pollutants and litter. Black Sea is an enclosed sea and it is very difficult to depollute. So it is necessary joint efforts to identify the origins and to reduce the erosion, the quantities of the non-point pollutants and litter that are reaching streams, rivers and the Black Sea. The study presents the traditional (erosion pins, Gerlach traps) and innovative (indices) methods applied for the quantification and estimation the surficial and stream bank erosion and litter by the Buzău-Ialomița Water Administration in the Protect-Streams-4-Sea project – BSB963 funded by Black Sea Programme.

2 Methods or Materials

2.1 Alluvial traps

The traps are built in V shape with straight wings specific to areas with higher slopes in order to collect all the runoff sediment. The locations are chosen in such a way that the slope is neither very low or very high, as well as the boulders that could fall off, won't damage the constructed trap. The installation of the traps for the collection of the material eroded and transported to the surface of the slope was carried out in very difficult conditions due to the high slope, the nature of the land and high degree of humidity.

The traps were made by placing some wooden support pillars, to which a geosynthetic fabric was attached, allowing the water to drain but in the same time to retain the eroded material transported on the slope. This material was attached to the support pillars. Barbed wire was used to protect the geotextile from the top, which was placed over the front of the trap to protect it from the animals or other shocks that could cause it to crack/perforate. The geotextile used is nonwoven, made of black polypropylene fibers and heat-fixed on both sides (fig.1 and 2).

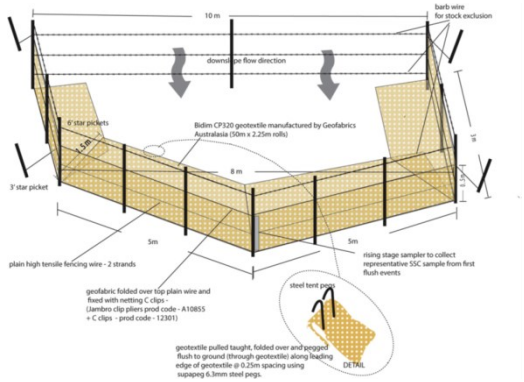

Fig.1.Sketch of a type alluvial Gerlach trap

Fig.2.Alluvial trap installed

2.2. Pins

This widely-used method consists of fixing a pin into the ground so that the top of the pin provides a location from which changes in ground surface level can be measured.

Thus, in the lower part of the Wind Pit landslide from the Siriu reservoir, a number of 9 pins made of wood were installed, at a distance of 60 m from each other in an altitude range between 564-624 meters. The second section used is located on the left side of the Buzau River near Păltineni locality. A number of 6 pins have been installed. They are made of wood as well and placed at a distance of 30 m between them in an altitude range between 348-389 meters. The position of each pin has been identified in the field using a GPS and there were monitored with a certain frequency. By installing these pins, it is aimed at quantifying the mass shifts of field slip.

Fig.3.The pins installed to determine the current mobility of the Wind Pit landslide from the Siriu reservoir and the Păltineni landslide - the left slope of the Buzau River

2.3. Vegetation indices

In order to identify and map the most vulnerable areas at surface erosion within Black Sea BSB963 project pilot area, NDVI - Normalized Difference Vegetation Index and NDWI - A Normalized Difference Water Index were applied in GIS environment. The NDVI and NDWI

indices were used starting upstream of Siriu Reservoir until downstream of Buzau River near Pătârlagele locality.

In order to calculate the NDVI and NDWI indices for the pilot area, it was necessary to download and use Sentinel-2 satellite images. For data processing and calculation of NDVI and NDWI values it was used the software ArcGIS 10.8.

3 Results

3.1 Alluvial traps

The campaigns for measurements started in May and ended in October 2021. During the first inspection, although the month of June was rich in precipitation (183 mm), no alluvium was generated on the surface of the slope, the high degree vegetation coverage protected the soil. Under these conditions, no alluvium was collected in the traps.

Even if the vegetation was not so abundant during the second inspection performed in October, no amounts of alluvial material were collected in the installed traps [1].

3.2 Pins

Looking at the determined values, an horizontal movement is observed, especially a horizontal change in the field.

The mass movement of the lower body of the slip is not influenced only by falling precipitation or water flowing to the ground surface. The position of the water level in the Siriu Reservoir is an important factor in fostering slip displacement.

Obviously, when there is a low level of water in the reservoir and on a humid background possibly accompanied by seismic waves generated by the variations in volume or from the seismic center of Vrancea, the landslide can be reactivated.

The same situation is for Paltineni landslide. A partial displacement of the upper part, with an accumulation at the level of pin two, so that then towards the base of the slope a mass displacement of the entire slope can be identified [2].

3.3. Vegetation indices

The results obtained indicate the characteristic ranges by category. The area under investigation is homogeneous, only the areas of Siriu Reservoir and localities are situated are different. The values presented in the maps and charts obtained in the study indicate the nature of the area from this point of view (fig.4), [3].

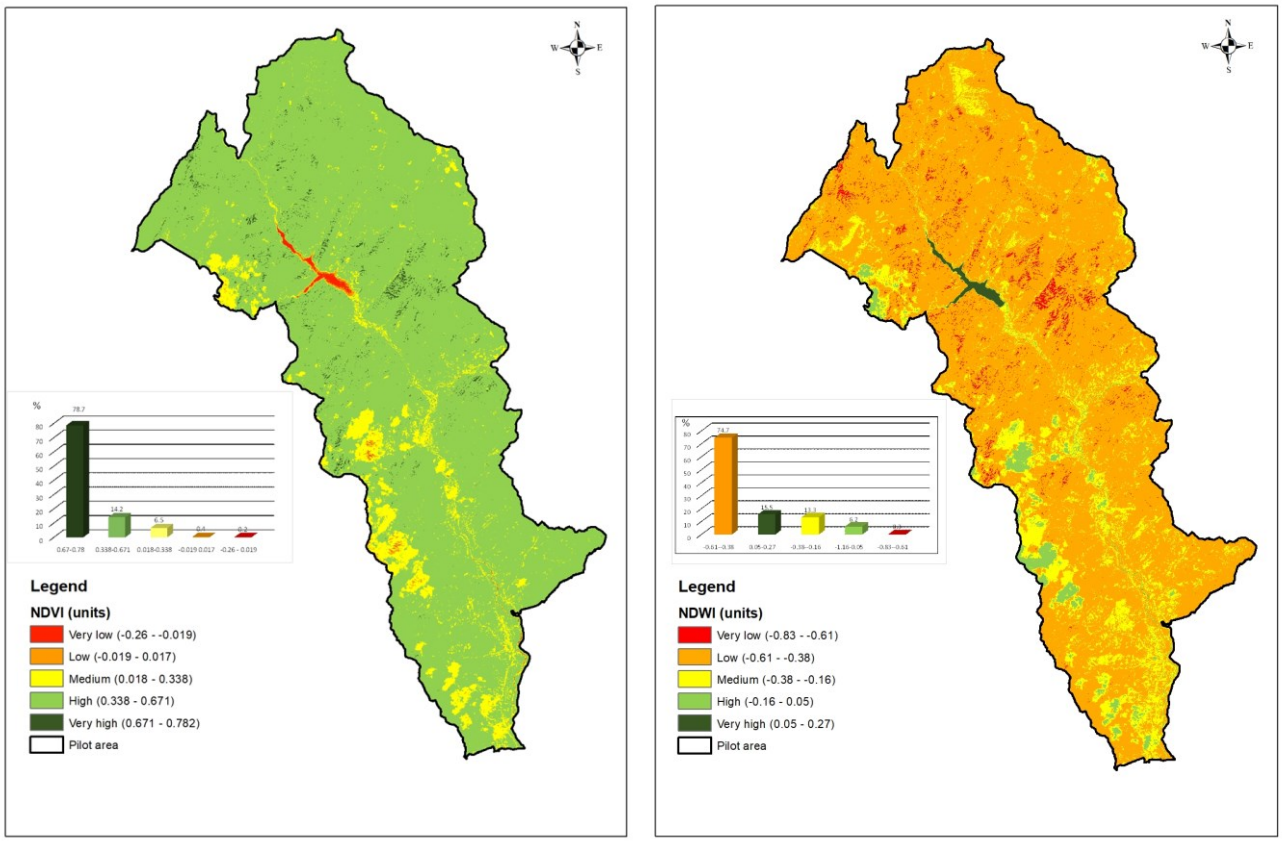

Fig.4.NDVI and NDWI maps of the Romanian pilot area

4 Discussion and conclusions

4.1. Alluvial traps

Correlating the data obtained through measurements from the surface of the land with what happens in the lower and middle areas, the following conclusions resulted:

1. Vegetation provides high soil protection;
2. The alluvial material that reaches the hydrographic network is not generated by the degradation of the soil resulted from the erosive action of precipitations;
3. The water from the precipitation contributes to the moistening of the land, especially in depth, which generates, in combination with the slope and the geological nature, a displacement in the mass of the land;
4. The study carried out within the BSB963 project proves that the process of erosion and land degradation is predominantly generated by the geological and lithological nature of the slopes of the Buzau River valley.

4.2. Pins

The results obtained can serve as a basis for further research that can be developed within this pilot area of the BSB 963 project.

The research of soil erosion prediction is developed gradually with the research of soil erosion mechanism. The ultimate goal of soil erosion model is to accurately predict the soil erosion in a certain area.

Looking at the data obtained from the field surface measurements with what is happening in the lower and middle areas, the following was found:

1. Alluvial material reaching the hydrographic network is driven by washing by water currents;
2. The slope of the terrain is an important factor in the movement of the material;

3. The material from the slopes is driven through intermediate stages: Material accumulation, its slight movement toward the hydrographic network, erosion and material transport from the bottom of the slope;

4. The slope of the slope varies according to the basic parameters (slope, geology, land use), but especially climatic and hydrological parameters (precipitation, infiltration, level, current speed, etc.).

4.3. Vegetation indices

Water indices derived from satellite data are used efficiently in water resource management. This study analyzed water body detection capabilities using the NDWI model. In contrast to commonly used methods, the accuracy of the assessment of the water areas detected by the NDWI was good. The main findings of this study are as follows:

- NDWI (Green, NIR) was the best model for detecting the body of water;

The fact that the surroundings of the Siriu reservoir are covered by natural vegetation (trees, meadows) has been a major factor in the success of the NDWI use.

- when the reservoir surface grows and water interacts with the land cover classes at the reservoir boundary (figure 9), the NDWI performance is affected.
- all data sets of the NDWI models with a special resolution of 10 m produced better results than those with a resolution of 60 m.
- time differences between remote sensing data acquisition and measurement data can increase the detection error of the body area in dynamic lakes such as the one studied.

During the warm season, changes in vegetation status produce corresponding dynamic variations in the time profile of the NDVI. Surfaces susceptible to river erosion are the banks of the Buzau River and the slopes of the Siriu Reservoir. Where there have been old careers, there are also surfaces susceptible to erosion. In the context of the pilot area of the BSB 963 project, the relatively small areas used for agriculture make it possible not to vary widely in space.

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[2] Study on field erosion trend study from the Paltineni - Nehoiu analysis section and the Siriu Lake, using traditional methods – erosion pins developed by SC ROCALEMN SRL within the project BSB963

[3] Study on Identification of areas vulnerable to erosion through the use of NDVI and NDWI indices and the development of GIS maps with the mapping of the most vulnerable large-scale areas of the pilot area” - SC ROCALEMN SRL, 2021

Project funded by EUROPEAN UNION

Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

Effects of stream size and geomorphological location on riparian areas

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ABSTRACT

The aim of the present study is to survey and compare the morphometric characteristics of the woody riparian vegetation of Nestos River, Aggitis River and Monastiraki torrent of Drama and Serres Prefectures of Greece. In each river/torrent 15 plots were selected, 7 of which were along meanders and the other 8 straight reaches. In each plot the height, diameter, crown (start height and width) of the woody vegetation was collected. Digital imaging of the measurements was done using the Stand Visualization System (SVS) software. Geographical information systems (GIS) were also used to map the land uses of the three study areas. The results show that the size of the river and its geomorphological position affect the morphological characteristics of the riparian tree vegetation.

Keywords: riparian vegetation, geomorphology, meandering, geographic information systems, stand visualization system

1 Introduction

Rivers and riparian areas have an important place in the environment due to the high biodiversity who have in relation to neighboring areas (Naiman et al. 2005, National Research Council 2002). They provide many important ecological services to humans, but have been and are strongly affected by many anthropogenic pressures (Iakovoglou et al. 2013). There are many cases of rivers and riparian areas in Greece that show significant degradation (Zogaris et al. 2007, Zaimes et al. 2011). The most frequent disturbances to riparian areas are deforestation for agricultural purposes. Other frequent disturbances are sand mining, water pollution as well as its pumping for water supply and irrigation purposes.

The extent of riparian area in a watershed is small but its ecological importance is disproportionately large for that watershed (Zaimes et al. 2010). The ecological functions provided by riparian areas are (Naiman et al. 2005, National Research Council 2002): a) Habitat for many species of wildlife. b) Very productive forest ecosystem because even during the

summer season it has access to water and nutrients (due to the water table). c) It supplies dead trees and logs, which are used as refuges for fish and terrestrial fauna and also as nuclei for the creation of islets and new riparian areas. d) It acts as a natural filter that holds pesticides and fertilizers from agricultural crops and keeps river water clean. e) Holds soil and reduces erosion. g) It shades the river water with its vegetation, preventing aquatic vegetation from growing and keeping its temperature low. f) Stores water during floods by supplying the underground aquifer while receiving water from it during periods of water scarcity. h) It reduces the light intensity inside creating a different climate (microclimate). i) During periods of flooding, they provide the fish with shelter so that they are protected from the rushing waters. j) Aesthetic upgrading of landscapes. The above functions make imperative the need for the sustainable management of coastal areas in Greece (Zaimes et al. 2011). Necessary for their sustainable management is the understanding of their peculiarities and great diversity. To achieve an understanding of riparian areas it is important to carry out traditional measurements (field measurements) that will be combined with new technologies (use of software) (Savopoulou et al 2017). The purpose of this specific work was to investigate differences in morphological characteristics of the riparian vegetation. The parameters studied to capture the morphological differences in the vegetation were geomorphological positions (straight sections or stream meanders) as well as the size of the rivers (large, medium and small).

2 Materials and Methods

As study areas, three streams of different sizes were chosen in the prefectures of Drama and Serres in order to see if there are differences in vegetation depending on the size of the stream and the water flow. Specifically, they were a) the Nestos River as a large stream, b) the Aggitis river as a medium stream and c) the Monastiraki stream as a small stream (Fig. 1).

Nestos Potamos

The forest complex to which the river Nestos belongs extends to Mountain Falakro and the Western Rhodopes. Its waters pass through the Prefectures of Drama, Xanthi and Kavala before they flow into the Aegean Sea. The study area extends from the dam of Platanovrisi to the village of Paranesti in the Prefecture of Drama, with the length of the river between these two points reaching almost 12.6 km.

Aggitis Potamos

Agitis is the largest tributary of Strymons. It crosses the Prefecture of Drama and the province of Phyllida in the Prefecture of Serres in Eastern Macedonia. The study area extends over a length of the river of approximately 3.7 km in the area of Krinida, Serres. The human presence is intense due to intense agricultural activity.

Monastiraki stream

The stream begins at the foot of Mount Falakrou, passes parallel to the village of Monastiraki of Drama to end up in the city of Drama. The study area begins approximately 2.5 km north of the Drama Hospital. The presence of man is intense due to the large agricultural and animal husbandry activity.

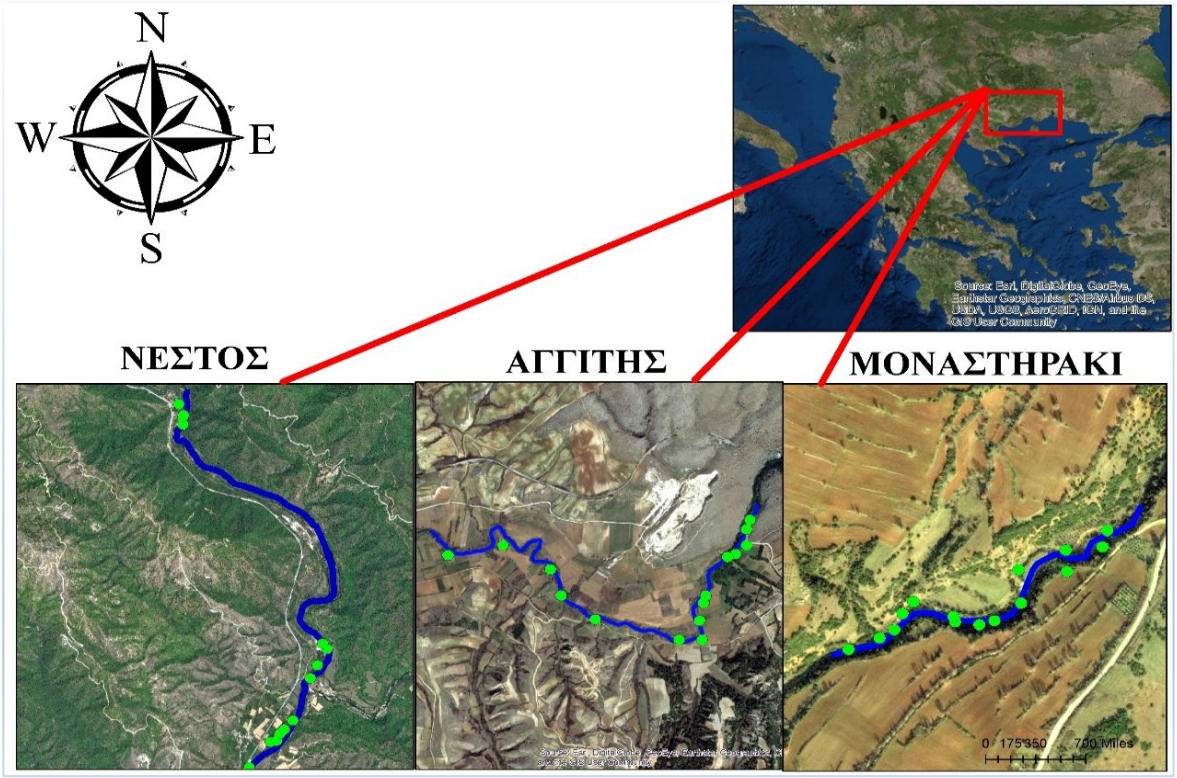


Figure 1. The general study area was in the Prefecture of Drama. Three streams were selected (Nestos, Agitis and Monastiraki). In each stream with blue lines are the 15 random sections where field measurements were made (source: googlearth).

Specifically, 15 sections were randomly selected in each stream, of which 8 are straight and 7 are meanders (Fig. 1). A 10x5 area (10m long parallel to the stream - 5m wide perpendicular to the stream) was defined in each section. In each demarcated area, height, diameter, initial crown height and crown opening were measured on all included trees. In each demarcated area, we also recorded all types of trees and any problems or disturbances such as wind erosion, diseases, logging, flooding, etc. Finally, with the help of the GPS and the compass, we got the coordinates of each section and its altitude.

Use Stand Visualization System (SVS)

The Stand Visualization System creates digital images of various profiles that provide an easy-to-understand representation of stand conditions in a stand of trees and shrubs. The images created help the manager to draw important conclusions regarding the management plan of the stand. In this particular research, SVS was used for the digital imaging of the sections in which the field measurements were carried out and at the same time to reveal the size of the crown and trunks of the trees of each section. SVS also gives the possibility to test any interventions (e.g. tree thinning).

Use of Geographic Information Systems (GIS)

GIS is a digital system in which the user can place or even retrieve geographic information to analyze, process and present it. With a very large range of separate tools, it can offer a lot of different information depending on the needs of each user. Data taken by GPS in the field were entered into GPS software. With the help of the GIS, we mapped the sections from which we took measurements, digitized the streams we used and found land uses based on Corine 2006-12 adjacent to the riparian areas.

3 Results

The size of the stream influenced the morphological characteristics of the riparian vegetation. Specifically, the vegetation next to the Monastiraki stream had the smallest height and the smallest diameter (Fig. 2) but the largest number of different types of trees compared to the two rivers.

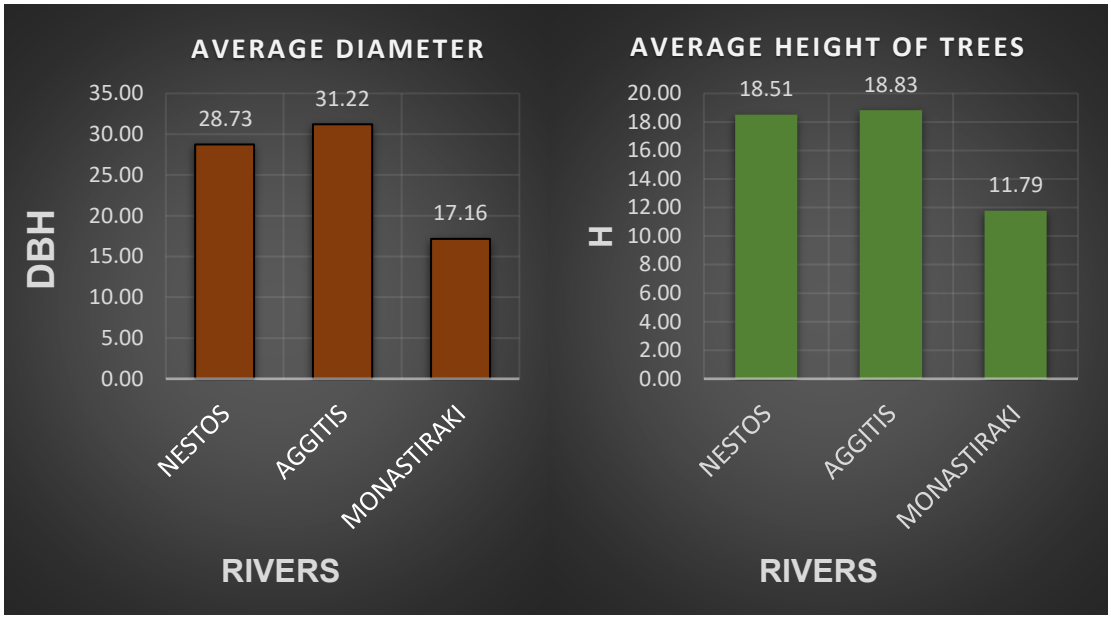
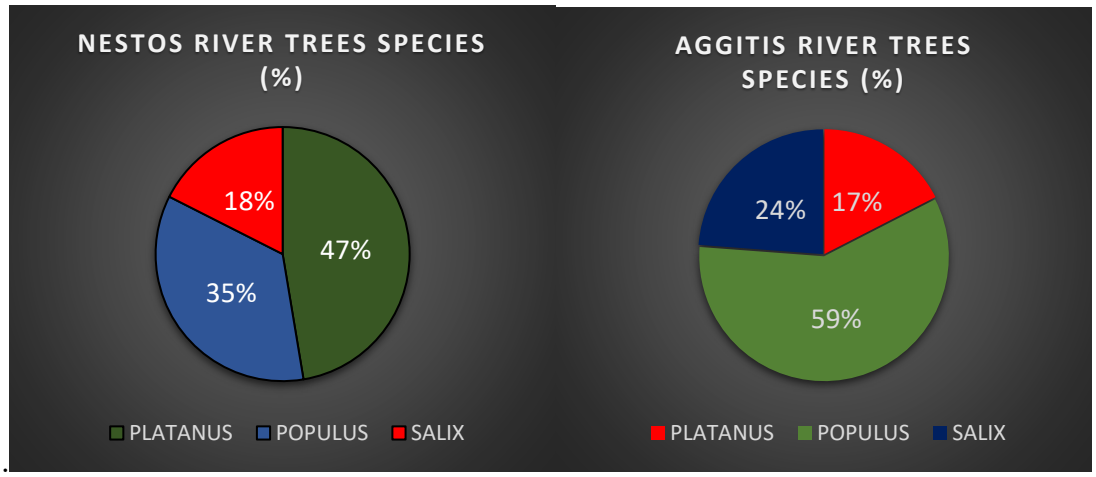


Figure 2. The average diameter and average height of woody vegetation of the 15 plots recorded

There were also differences depending on the geomorphological location. In the Nestos River, the surfaces next to the straight sections had the largest diameter and the highest height, while the surfaces next to the internal meanders had the smallest (Fig. 2). In the Aggitis Potamos and the Monastiraki stream, the surfaces next to the straight sections had the largest diameter, while the surfaces next to the external meanders had the smallest (figs. 5 and 6). For the height of the trees in Agitis Potamos, the relationship was the opposite to the previous one, with the surfaces next to the external meanders having the largest and the surfaces next to the straight sections the smallest (Fig. 5). Finally, in the Monastiraki stream, the surfaces next to the internal meanders had the highest height and the surfaces next to the straight section the smallest (Fig. 6).



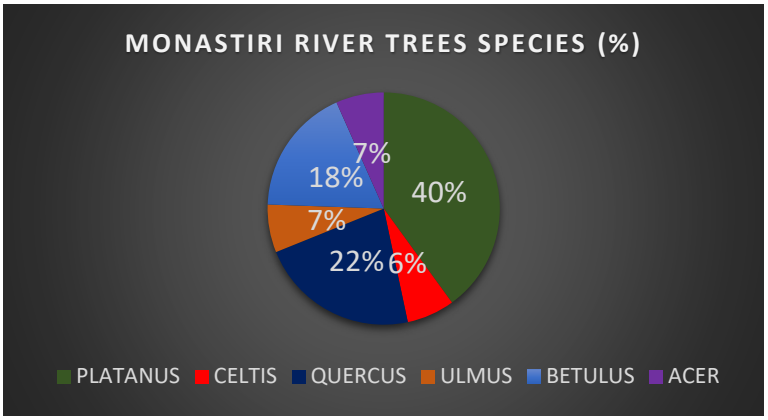


Figure 3. The types of woody vegetation in the three streams recorded in the 15 plots.

Figure 4. The average diameter and average height of woody vegetation at each geomorphological location in Nestos river.

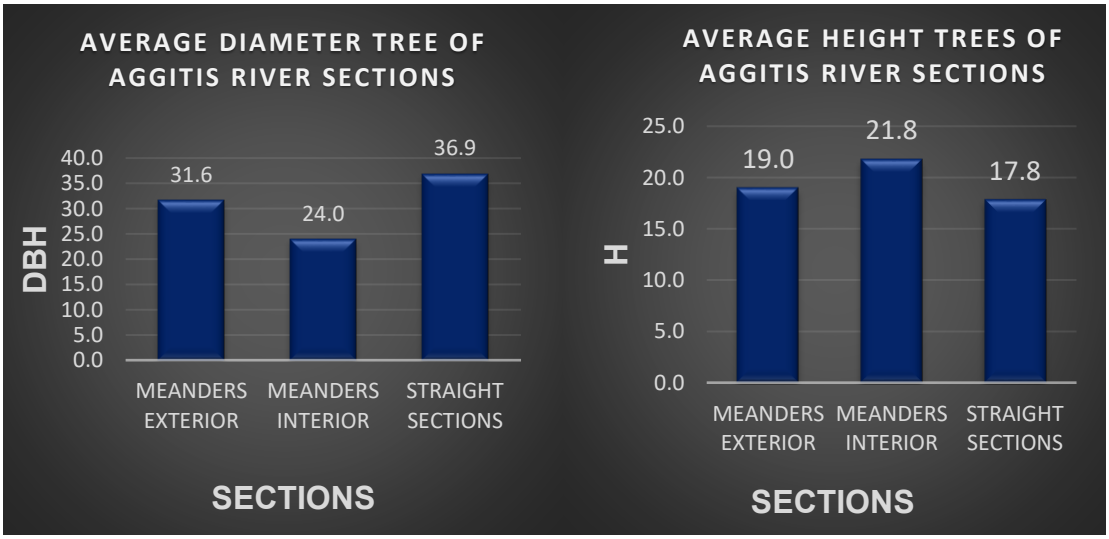


Figure 5. The average diameter and the average height of the woody vegetation in each geomorphological location in the Aggitis river.

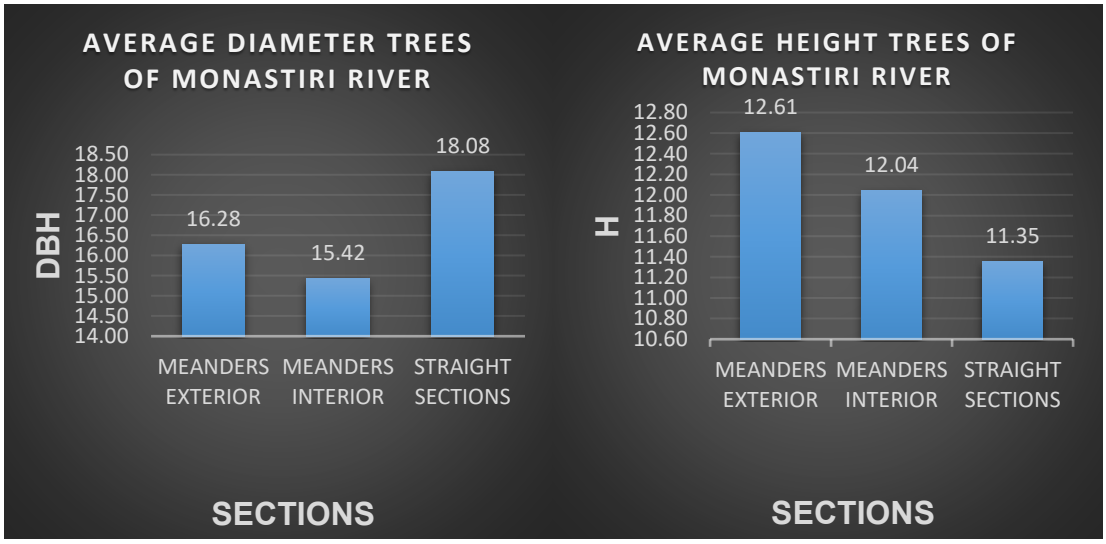


Figure 6. The average diameter and the average height of the woody vegetation in each geomorphological location in the Monastiraki stream.

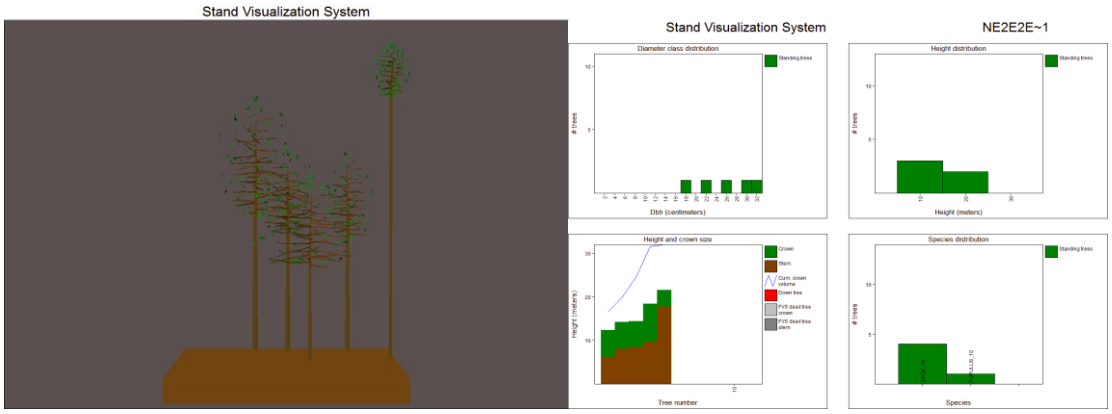


Figure 7. Digital section imaging using SVS

Inputting the data measured in the field into SVS gave the graphical representations of the surfaces (Fig. 6). Based on the illustrations, differences were found, both based on the size of the streams and the geomorphological positions (Fig. 6). Finally, with the use of GIS and Corine data, the different neighboring land uses in the riparian areas of the three studied streams were captured (Fig. 7).

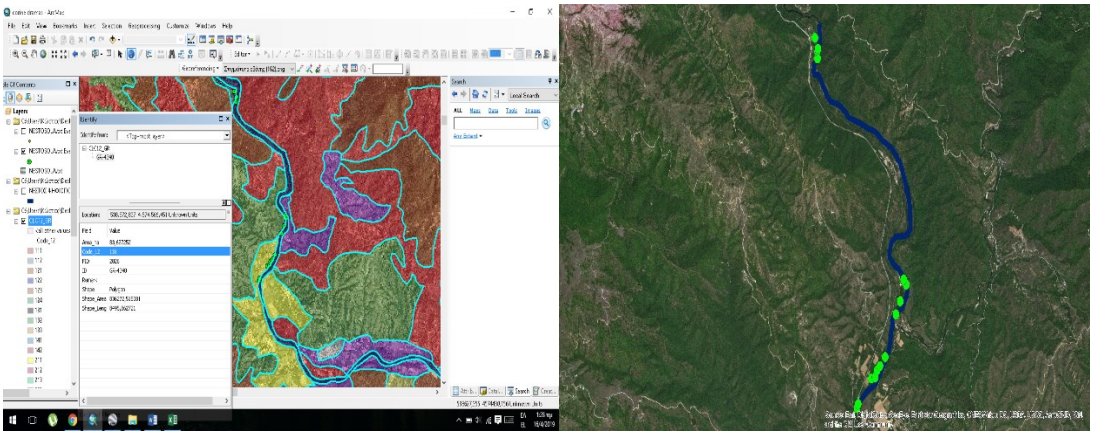


Figure 8. Land uses in the riparian areas of Nestos based on Corine and the digitization of the river with the sections where the field measurements were carried out.

4 Discussion – Conclusions

The size of the stream and the geomorphology of the stream section influenced the morphological characteristics of the riparian vegetation. Malkinson and Wittenberg (2005) also found that geomorphology affects riparian vegetation in mountain streams in Israel. Specifically, the vegetation of the two rivers (Nestos and Aggitis) had the largest diameter and the highest height in relation to the vegetation of the stream. The main reason was the greater presence of more fast-growing species (Populus ssp. and Salix ssp.) (Athanasiadis 1986). In the riparian area of the stream because the conditions are not so wet, it gives the possibility for the development of less aquatic species and for this reason it had the largest number of different tree species.

Regarding the diameter of the trees of the riparian vegetation, the straight sections were the largest in relation to the meanders. This is due to the fact that straight sections have less disturbance (e.g., erosion and deposition of transported materials) than meander sections. This pattern was not as evident with the altitude of the woody vegetation. Only in the Nestos river did the straight sections have the highest tree vegetation which shows that there are other factors influencing tree growth.

In total, we had 7 different land uses in the Nestos River, 4 in the Aggitis Potamos and 2 in the Monastiraki stream. The land uses in Nestos were: a) Mineral mining areas (Code 131), b) Transitional wooded shrub lands (Code 324), c) Broadleaf Forest (Code 311), d) Natural pasture (Code 321), e) Land covered mainly by agriculture with significant areas of natural vegetation (Code 243), g) non-irrigated arable land (Code 211), and the) Intermittent urban construction (Code 112). The land uses in the Aggitis River were: a) non-irrigated arable land (Code 211), b) Mineral mining areas (Code 131), c) Land covered mainly by agriculture with significant areas of natural vegetation (Code 243), and Natural Pasture (Code 321). Finally, the land uses in the Monastiraki stream were: a) Non-irrigated arable land (Code 211), b) Natural pastures (Code 321).

Based on the results of this research, for the successful restoration and sustainable management of the vegetation of the riparian areas, it is necessary to take into account the size of the streams and the geomorphology of the sections of the stream.

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

Research on changes in some soil properties with land uses in the Arhavi Sub-basin, Artvin, Turkiye

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ABSTRACT

This study aimed to determine the differences in certain soil properties, including texture, bulk density, organic matter, pH, with different land uses in the Arhavi Sub-Basin, Artvin, Turkiye. For these purposes, soil samples were taken from 150 sampling points located in areas of four different land uses (tea, hazelnut, forest and grassland) and two soil depths (0-15 cm and 15-30 cm). Some of the studied soil properties (texture components (sand %, clay %, silt %), organic matter %, bulk density (gr/cm^3), soil reaction (pH)) changed in according to land uses in both soil depth levels. Soil acidity was the most important problem threatening soil fertility in all land uses and elevation zones.

Keywords: Soil, Land use, Sub-basin, Soil-acidity, Soil erodibility factor

1. Introduction

Soil properties vary with the type of land use, soil depth and elevation. There are many national and international scientific studies showing that certain soil properties show statistically significant differences with different types of land uses [1-10]. Conversion of forests and grasslands into agricultural lands causes changes in some soil properties such as organic matter, pH, water holding capacity, nutrient contents etc. There are few studies done in the Eastern Black Sea Region on changes in soil properties with land use, soil depth and elevation [4-11].

On the other hand, elevation is often used to explain the effects of climatic variables such as temperature and precipitation on the dynamics of soil organic matter and nitrogen mineralization and C/N ratio, which determine the state of decomposition of organic matter [12,13]. Changes in elevation affect soil organic matter by controlling plant species and biomass production in natural and cultural areas, soil-water balance, soil erosion and geological deposition processes [14]. The goal of this study was to assess changes in some soil physiochemical properties (texture, bulk density (BD), organic matter (OM), soil pH with different types of land uses (tea and hazelnut, grassland and forest areas), and soil depths in the Arhavi sub-basin.

2. Materials and Methods

The research area is located at the Arhavi sub-basin with a surface area of 300 km^2, between 41^0 07' 00"- 41^0 21' 30" north and 41^0 15' 00"- 41^0 30 00" east within the Eastern Black Sea Region in northeastern Turkiye. The mean annual total precipitation of the research area is 2438 mm and the average annual temperature is 11.8 °C at sea level. The area has a typical very humid Black Sea climate with abundant rains in every season [15].

Soil sampling points were determined according to a stratified simple random sampling method [16]. The textures of soil samples were determined according to Bouyoucos' hydrometer method [17]; pH was determined according to the glass electrode method in a 1: 2.5 soil-water mixture [18]; organic matter according to the modified Walkley-Black wet combustion method [19]. The SPSS 19.0 package program was used for data processing and evaluation [20]. One-way ANOVA was used to determine whether soil properties differed according to land use types.

3. Results

3.1 Changes in some soil properties with land uses

The sand, clay, silt, organic matter, bulk density, pH values of the soils at 0-15 cm and 15-30 cm depth levels differed significantly ($p<0.05$) according to land uses. The sand values of soils at 0-15 cm and 15-30 cm soil depth were significantly higher in grassland areas (72.5 % and 72.0 %) than in forest areas (65.3 % and 61.0 %), hazelnut areas (59.4 % and 57.7 %) and tea areas (55.4 % and 53.8 %), respectively.

The clay values of soils at 0-15 cm and 15-30 cm soil depth were significantly lower in grassland areas (6.2 % and 8.1 %) than in forest areas (12.9 % and 15.8 %), hazelnut areas (16.6 % and 18.5 %) and tea areas (15.8 % and 18.6 %), respectively. The silt values of soils at 0-15 cm and 15-30 cm soil depth were significantly greater in tea areas (28.7 % and 27.6 %) than in hazelnut areas (23.9 % and 23.8 %), forest areas (21.8 % and 23.2 %) and grassland areas (21.3 % and 19.9 %), respectively. The organic matter values of soils at 0-15 cm and 15-30 cm soil depth were significantly greater in grassland areas (12.0 % and 8.8 %) than in forest areas (8.2 % and 5.4 %), hazelnut areas (5.8 % and 3.8 %) and tea areas (6.9 % and 4.3 %), respectively.

The bulk density values of soils at 0-15 cm and 15-30 cm soil depth were significantly lower in grassland areas (0.8 and 0.9 gr/cm^3) and forest areas (0.7 and 0.9 gr/cm3) than hazelnut areas (1.0 and 1.0 gr/cm^3) and tea areas (0.9 and 1.0 gr/cm^3), respectively. The pH values of soils at 0-15 cm and 15-30 cm soil depth were significantly greater in grassland areas (4.1 and 4.2) and hazelnut areas (4.1 and 4.2) than in forest areas (3.9 and 4.0) and tea areas (3.5 and 3.6), respectively.

4. Discussion

The sand content of the soils at 0-15 cm and 15-30 cm depth differed significantly ($p<0.05$) according to land use and elevation zones. This difference may be due to the difference in soil texture and the amount of rainfall. Yüksek et al. [8] stated that the sand content of soils increases with the increase in elevation and depth in forest areas while Karagul [6] suggested that the difference in sand content according to land use can be explained by the fact that the change in topography and elevation in the basin affects climate weathering, washing and profile development and conditions.

The clay content of the soils at 15-30 cm depth varied significantly with land use ($p<0.05$). It was significantly lower in grassland areas (7.96%) than in forest areas (14.93%) in the >1000 m elevation zone ($p<0.05$). Similar results found by Tufa et al. [21]. Similar studies done in the region, Yuksek et al. [7] and Yener et al. [11] reported significantly lower clay content in forest areas than in tea areas.

Soil bulk density were significantly affected by land use types in this study and the some other studies[22, 23]. Tellen et al. [23] determined that the bulk density significantly different according to the land use and elevation. The lower bulk density in forest and grassland areas compared to tea and hazelnut areas may be due to the higher organic matter content. The organic matter content of soils decreases with tillage in agricultural areas and the stacking order of soil particles is disrupted and the infiltration capacity of soils decreases with people making use of the land, increasing soil loss by surface runoff and erosion. The fact that the bulk density values of the soils in pasture areas are higher than those in forest

areas can be explained by soil compaction due to intensive animal grazing in pasture areas and the increase in the amount of soil per unit volume.

The organic matter of the soils at 0-15 cm and 15-30 cm depth showed significant ($p<0.05$) differences with land use. Further, the organic matter content of soils at 0-15 cm depth for all land uses in all elevation zones was significantly higher than at 15-30 cm depth ($p<0.05$). Shamsher et al. [24] determined that soil organic matter content differed significantly according to land use, that organic matter content in forest areas was significantly higher than in grassland and agricultural areas at all depth levels, and that organic matter content increased with increasing elevation and decreased with increasing soil depth. Similarly, Tellen et al. [23] and Khaldoon et al. [25] determined that the soil organic carbon differed significantly according to the land use. Tufekcioglu [9] reported that organic matter content of soils at 0-30 cm depth level was greater in forest areas than in grassland areas.

Soils of the study area are fall in the extremely acid soil class. There are many studies indicating that the pH of soils signifcantly differs according to land use types [5, 26, 27]. The fact that the pH of tea areas is extremely low compared to other areas is might be due to the long-term use of acidity-increasing fertilizers such as ammonium sulfate [28].

5. Conclusion and Recommendations

The results of this study revealed that the soils in tea and hazelnut gardens, forests and grasslands in Arhavi sub-basin showed significant differences in terms of sand, clay, silt, bulk density, organic matter and pH properties with land use and soil depth. K values of soils were in the low erosion class and did not differ significantly with land use, elevation zone and soil depth. Increasing soil acidity was the most important problem in all land uses that was threatening soil fertility. Use of soil-acidity-increasing fertilizers such as ammoium sulfate in tea gardens should be eliminated in the the region to protect the fertility of soils.

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Protect-Streams-4-Sea

Black Sea CROSS BORDER COOPERATION

Proceedings of the International Conference “Protecting water resources with nature-based solutions - PS4S-2023”

Editors: George N. Zaimes, Valasia Iakovoglou, Paschalis Koutalakis

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