



Soil Erosion and TOrrential Flood
Prevention: Curriculum Development at the
Universities of Western Balkan Countries



SETOF CONFERENCE

ABSTRACT BOOK

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CONTENTS

SETOF CONFERENCE	
TOPIC 1. SOIL EROSION ASSESSMENT – MECHANISM/PROCESSES, MODELING, AND MAPPING	
TORRENTIAL FLOODS PREVENTION Ratko Ristić – keynote speaker	4
STUDY OF SOIL CHARACTERISTICS IN SEDELSKA RIVER WATERSHED Kameliya Petrova, Blagoy Koichev	5
UTILIZATION SUITABILITY INDEX (USI) OF TECHNOSOLS: CASE STUDY OF KAKANJ MUNICIPALITY Emira Hukić, Muhamed Bajrić, Hamid Čustović, Melisa Ljuša, Kristina Kovačević	6
RISK ASSESSMENT OF SOIL EROSION IN THE AREA OF THE SOURCE OF WATER SUPPLY RZAV Ana Stojanović, Tijana Vulević, Siniša Polovina, Nada Dragović, Mirjana Todosijević	7
MODIFICATION OF SOME PARAMETERS IN EPM AND RUSLE METHODOLOGY Ivan Blinkov, Aleksandar Trendafilov, Dusko Mukaetov, Ivan Minchev, Bozin Trendafilov	8
USE OF INEXPENSIVE UAV SYSTEMS FOR ENVIRONMENTAL APPLICATIONS (CASE STUDIES REVIEW) Ivan Minchev	10
EVALUATION OF VULNERABILITY TO SOIL EROSION USING GIS AND AHP CONSENSUS MODEL Milica Vranešević, Boško Blagojević, Atila Bezdán, Radovan Savić, Aleksandar Baumgertel	11
CHARACTERISTICS OF DYSTRIC CAMBISOL IN THE FOREST MANAGEMENT UNIT "LISINA" Ilija Čigoja, Marijana Kapović Solomun	12
DRIPPING RAINFALL SIMULATORS DESIGN FOR SOIL RESEARCH Vukašin Rončević, Nikola Živanović, Ratko Ristić, John van Boxel, Milica Kašanin-Grubin	13
EXPERIMENTAL RESEARCH OF SOIL RESISTANCE USING PORTABLE FIELD RAINFALL SIMULATOR Nikola Živanović, Vukašin Rončević, Stevan Ćorluka, Vladimir Čebašek, Milica Kašanin-Grubin, Snežana Štrbac, Nevena Antić	14
WATEM/SEDEM VERIFICATION BY SOIL TRUNCATION METHOD (MOSCOW REGION, RUSSIA) Daria Fomicheva, Nadezhda Ivanova, Andrey Zhidkin, Evgeniya Shamshurina	15
USING POLYMERS TO REDUCE WATER EROSION IN SOILS Ekaterina Dorogaya, Ruslan Suleymanov	16
APPLICATION OF THE RUSLE MODEL IN THE ASSESSMENT OF SOIL EROSION USING THE RCP 8.5 CLIMATE SCENARIO Siniša Polovina, Boris Radić, Ratko Ristić, Vukašin Milčanović, Nikola Živanović	17
SOIL EROSION RATES BASED ON ANATOMICAL CHANGES IN EXPOSED ROOTS – CASE STUDY FROM SOUTHWEST BULGARIA Dimitar Dimitrov, Eli Pavlova-Traykova	18
TOPIC 2. TORRENTIAL FLOODS – GENESIS, IMPACTS, RISKS	
THE METHOD OF CRITICAL POINTS AS A TOOL FOR IDENTIFYING FLOOD RISKS IN THE CZECH REPUBLIC Miroslav Dumbrovský	20
PRIORITIZATION OF TORRENTIAL FLOODS VULNERABLE WATERSHEDS UPSTREAM FROM THE "ROVNI" WATER RESERVOIR USING TOPSIS METHOD Natalija Momirović, Tomislav Stefanović, Tijana Vulević, Nada Dragović, Stanimir Kostadinov, Katarina Lazarević, Sonja Braunović	21

STUDY ON WATER RUNOFF AT ECOLOGICAL STATION "IGRALISHTE" Eli Pavlova-Traykova	22
GIS APPLICATION FOR HYDROLOGICAL FEATURES PREVIEW OF FLOODPLAIN FORESTS Vesna Nikolić Jokanović, Dušan Jokanović, Radovan Savić, Aleksandar Anđelković	23
TOPIC 3. PREVENTION AND MANAGEMENT OF SOIL EROSION AND TORRENTIAL FLOODS	
THE INFLUENCE OF THE STRUCTURAL CHARACTERISTICS OF THE STAND ON THE WATER REGIME ON THE EXAMPLE OF SCOTS PINE FOREST CULTURE ON LIMESTONE IN SOUTHWESTERN BOSNIA Adnan Hodžić, Čemal Višnjić, Muhamed Bajrić, Mirjana Todosijević	25
THE INFLUENCE OF THE FUNCTIONALITY OF WATER-PERMEABLE STRUCTURES ON MOUNTAIN WATERCOURSES AND THE PRIMARY NETWORK OF FOREST TRANSPORT INFRASTRUCTURE Amina Čaluk, Muhamed Bajrić, Emira Hukić, Nada Dragović	26
ON THE CONNECTION BETWEEN STANDARDIZATION AND SOIL EROSION AND PREVENTION OF FLASH FLOODS Dejan Vasović, Snežana Živković, Tatjana Golubović, Slobodan Milutinović	27
IMPACT OF PROTECTIVE FOREST BELTS ON WIND SPEED REDUCTION AND AIR TEMPERATURE CHANGE, A CASE STUDY Aleksandar Baumgertel, Sara Lukić, Milica Caković, Stefan Miletić	28
MODELLING OF A TORRENT CHECK DAM IN THE DUBOKI POTOK BASIN Gordana Đukanović, Aleksandar Anđelković, Đorđe Đorđević, Vesna Nikolić Jokanović	29
TOPIC 4. MANAGEMENT OF SUSTAINABLE DEVELOPMENT IN DEGRADED AREAS	
NATURE-BASED DISASTER RISK REDUCTION IN SERBIA Miodrag Zlatić, Stanimir Kostadinov	31
THE EVALUATION OF ECOSYSTEM SERVICES - DEVELOPMENT OF THE METHODOLOGY IN SERBIA Mirjana Todosijević, Gordana Krsmanović, Katarina Lazarević, Nada Dragović, Tijana Vulević	32
AN ECOSYSTEM APPROACH TO NATURAL RESOURCE MANAGEMENT: CASE STUDY OF THE TOPČIDERSKA RIVER, SERBIA Katarina Lazarević, Mirjana Todosijević, Natalija Momirović, Nada Dragović, Ranka Erić	33
APPLICATION OF SIMPLE ADDITIVE WEIGHTING METHOD FOR SELECTION OF APPROPRIATE MEASURES IN THE REHABILITATION OF THE LANDSLIDE Jovana Cvetković, Tijana Vulević, Grozdana Gajić, Nikola Živanović, Vukašin Rončević	34
INTEGRATED WATERSHED MANAGEMENT – TRENDS AND PERSPECTIVES Filip Vasić, Miodrag Zlatić, Nada Dragović, Nikola Jovanović, Milica Caković	35

PREFACE

Soil erosion and torrential floods are destructive processes, with serious consequences on the economy, society, and environment. Compared to large river floods, torrential floods occur suddenly, for a couple of hours after the rains of high intensity and therefore the defense against torrential floods is much more complex than in the case of large rivers. Due to climate change, which is also pronounced in the region of the Western Balkans, the intensity of erosion, and frequency and intensity of torrential floods will increase in the future.

Considering these facts, there is a need for a more detailed study of the problems of erosion and torrential floods and opportunities for the control of these destructive processes. For graduates to know the necessities for soil and torrent control, it is necessary to improve and modernize the existing study programs and develop a new master's program. This goal is achieved through the implementation of the Erasmus+K2 project "Soil Erosion and Flood Prevention: Curriculum Development at the universities of Western Balkan countries (SETOF)".

THE LEAD PARTNER of the SETOF project is the University of Belgrade (Faculty of Forestry). Members from partner countries are the University of Novi Sad, the University of Niš, the University of Banja Luka, the University of Sarajevo, and the Institute for Forestry (Belgrade). Members from program countries are BOKU University (Austria), University of Mediterranean, Reggio Calabria (Italy), and University Ss. Cyril and Methodius in Skopje, Hans Em Faculty of Forest Sciences (North Macedonia), and Forest Research Institute at the Bulgarian Academy of Sciences (Bulgaria). Associated members are the Serbian Chamber of Engineers, Forest Management Unit "Donjevrasko" Banja Luka, and Cantonal Public Company "Sarajevo-forests". Five universities from Serbia and Bosnia and Hercegovina are participating in the development and implementation of a joint master study program "Soil Erosion and Torrential Flood Prevention".

At the final conference of the SETOF project, the scientific papers of the project participants and other experts dealt with the study of soil and water resources. The Conference is organized into four topics. The participants of this conference deal with problems related to soil erosion assessment (mechanism/processes, modelling, and mapping), torrential floods (genesis, impacts, risks), prevention and management of soil erosion and torrential floods, and management of sustainable development in degraded are.

Nada Dragović

SOIL EROSION AND TORRENTIAL FLOOD PREVENTION: CURRICULUM DEVELOPMENT AT THE UNIVERSITIES OF WESTERN BALKAN COUNTRIES

SETOF

LEAD PARTNER – UNIVERSITY OF BELGRADE



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Associated members



TOPIC 1

Soil Erosion Assessment

(Mechanism/Processes, Modeling, and Mapping)

TORRENTIAL FLOODS PREVENTION (KEYNOTE)

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Abstract: Torrential floods are the most frequent phenomenon in the arsenal of "natural hazards" in Europe and globe, being the first when it comes to losses, causing huge damage and the loss of human lives. Torrential events are characteristic both in urban and rural landscapes. Appearance of torrential floods is consequence of factors which are partly or completely out of man control. Climate, specific characteristics of relief, distinctions of soil and vegetation cover, social-economic conditions have resulted in the occurrence of erosion processes and torrential floods. Anthropogenic influence could be increased by irresponsible activities concerning land use or decreased with preventive activities: spatial planning in endangered watersheds; afforestation of bare lands, amelioration of degraded forests, meadows and pastures; appropriate agricultural techniques; application of agroforestry; erosion control measures and torrent training works. Soil bioengineering works in the headwaters lead to improvement of interception effects and infiltration-retention capacity of soil. Performing of erosion and torrent control works in line to Nature Based Solution (NBS) and Land Degradation Neutrality (LDN) could be the way for decreasing of natural and man-made hazard.

Keywords: torrential floods, nature-based solutions, land degradation neutrality, erosion and torrent control

STUDY OF SOIL CHARACTERISTICS IN SEDELSKA RIVER WATERSHED

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Abstract: The subject of the research is soil characteristics of soils developed under different types of forest crops in the watershed of the Sedelska river. The watershed is a part of Struma River watershed, which is a right tributary with torrential characteristics. A large scale of vegetation restoration activities has been conducted on the territory of Sedelska River because of the ongoing severe erosion processes. This method for mitigating the consequences of soil erosion is widely adopted, but still, it is not clear which type of forest vegetation has the best capacity for improving environmental conditions and soil characteristics. A total of 32 soil profiles were set on the field. The studied soil units were developed under the influence of five different types of tree species. Soil samples were taken, and main soil characteristics have been analysed. When setting the profiles, the exposure, and the type of the slope (upper part, middle part, and lower part) were considered. The established low content of org. C and nitrogen in all soil samples indicate the presence of erosion processes in the watershed. Soils are shallow and sandy. Higher values of org. C were established in soils developed on the lower part of the slope.

Keywords: soil, erosion, Sedelska River

UTILIZATION SUITABILITY INDEX (USI) OF TECHNOSOLS: CASE STUDY OF KAKANJ MUNICIPALITY

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Abstract: Technosols are commonly located in urban areas where basic infrastructure already exists and their redevelopment should be based on objective suitability assessments in favor of public health and well-being. Despite the existing potential, technosol reclamation faces significant obstacles due to high clean-up costs, insufficient investment resources, uncertain timelines, and liability associated with contaminated properties. The goal of this study was to analyze and discuss an indexing scheme that planning agencies can employ to scan large areas and initially identify Technosol sites that could be redeveloped under four main land uses, forest, pasture, and agricultural land. We explored the applicability of the index in which we incorporated the level of degradation, evaluated land quality (environmental and livability) and socio-economic variables into a mapping index that is visualized in a Geographic Information System (GIS). We demonstrate the application of the Technosol utilization suitability index (USI) by analyzing characteristics of land areas by using the industrial town Kakanj as a case study. The main factors of land degradation in Kakanj are mining and the electric power industry. Technosols are located in the urban and peri-urban zones of the city having a huge impact on the environmental quality. By using satellite images analyzed with a GIS tool in combination with on-site surveys we assessed the different Technosol categories. To evaluate land quality, we used the national framework for agricultural land for rating selected categories of Technosol. Also, we calculated the ratios between degraded land compared to a forest, agricultural, and construction land as an indicator of degradation level on a settlement level. Settlement population density and life standards were used as socio-economic indicators. Selected indicators were used to assess Technosol USI for the level of settlement. Technosol covers roughly 586 hectares of the territory of Kakanj, excluding Urbisol (urban soils) and Necrosol (graveyards) which are not involved in the survey. The largest area was in the category of Deposol (493 ha), followed by the categories Recultisol (50.7 ha), Cinerosol (30.1 ha), recultivated Cinerosol (6.56 ha), and Garbisol (5.48 ha). Technosols were rated as the lowest land quality categories VII or VIII. Considering the low level of land reclamation, Recultisols were rated as medium to low quality categories IV, VI, and VII. Land areas with the highest suitability and priority for reclamation were medium populated areas with the highest level of land degradation. They were followed by Deposol and Recultisol in densely populated settlements in the very urban zone of the city of Kakanj. Regarding the current land quality indicators Deposol, Recultisol, Cinerosol, and re-cultivated Cinerosol are the most suitable to be converted into forest land. If more advanced technical and biological recultivation measures are applied Deposol and Recultisols are also suitable to be converted in pastures and agricultural land. Garbisol is only suitable for conversion into controlled pasture land. This study explores the usage potential of Technosol and identifies locations with high priority for reclamation. The assessment shows that based on selected indicators Technosols could be easily converted into productive forest land. For community sustainability investments should be made in the most suitable areas for conversions into pasture and agricultural land.

Keywords: soil functions, soil degradation, land use, GIS tools, recultivation methods

RISK ASSESSMENT OF SOIL EROSION IN THE AREA OF THE SOURCE OF WATER SUPPLY RZAV

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Abstract: Soil is a key natural resource in providing basic human needs. Erosion is one of the primary and most common causes of soil degradation and reduction of soil quality both in the world and in the Republic of Serbia. Given that the emergence and development of the erosion process are influenced by a significant number of factors as well as their interrelationships, the study of erosion processes is a complex, long-term, often expensive process. To estimate soil losses as well as erosion risk levels, a large number of models are available today. Most of them are based on GIS logic thanks to their ability to sublimate heterogeneous information. In this work, the analysis of spatial degradation of natural resources was performed in the Veliki Rzav river basin. Soil degradation in the research area was analyzed using the Erosion Potential method. The method is characterized by a high degree of reliability for determining the intensity of erosion and calculations of the production and transfer of erosion sediments. Compared to others, the main advantage of this method compared to others is its lower demand for the number of input parameters, simplicity, as well as the possibility of its application in a GIS environment. In addition, the method has the advantage of choice, because it was developed in our area. The method starts with the analytical processing of data on the factors that affect erosion. As erosion is a spatial phenomenon, it is shown on the map according to the classification based on the analytically calculated erosion coefficient (Z), which depends on the characteristics of the soil, vegetation cover, relief, and visible presence of erosion. Using the Erosion Potential method, an erosion map was created, showing the spatial distribution of erosion processes in the Veliki Rzav river basin. The erosion map provides insight into the state of erosion processes of different intensities and characters.

Keywords: risk assessment, degradation, erosion models, erosion potential method, Veliki Rzav, GIS

MODIFICATION OF SOME PARAMETERS IN EPM AND RUSLE METHODOLOGY

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Abstract: Part of GEF – UNEP Project/program “Achieving Biodiversity Conservation through Creation and Effective Management of Protected Areas and Mainstreaming Biodiversity into Land Use Planning” was a component: Preparation of soil erosion and drought vulnerability map, and identification of high-risk zones and their impact to biodiversity. The main focus was the region vulnerable to desertification in North Macedonia. After developing of Drought vulnerability map, an Aridity Map, and a Map of the Region vulnerable to desertification, developed an Erosion map. For this purpose, were used 2 methods: RUSLE (to be compatible with the latest EU erosion Map, JRC 2015) and EPM (a methodology that is in use in the country for almost 40 years). For the preparation of the RUSLE map, was followed the methodology used during the preparation of the EU erosion map (JRC, 2015). The only parameter that was problematic was R-factor (rainfall erosivity factor) for whose calculation is necessary long-term data on rainfall intensity on various pluviometric stations. This type of data doesn't exist in the country. Various authors faced with the same problem tried to solve this based on an annual sum of precipitations. More than 20 various equations developed in various regions in the world, were tested and more of them resulted in very high values (even more than 4000) because of regional circumstances. Finally, were selected 7 equations, and the final result per 18 meteorological stations was calculated as a mean value of the results from selected equations. Then using linear regression with altitude was developed map of R-factor of the country. A comparison of our values with those near the border from Bulgaria and Greece shows that our approach is appropriate. For the EPM method, changes were done in auxiliary tables for calculation g (reciprocal value of the coefficient of resistance of the soil to erosion) and X_a (coefficient of protection of the basin/area and it takes into consideration the level of protection of the and from erosive forces in natural conditions (X) and artificial conditions (a)). Regarding $[g]$ - parameter, within the original methodology was used an old soil classification system by Skoric, Ciric, and Filipovski. Basic soil data is MASIS – Macedonian Soil information system. This system is used WRB (World Reference Base) classification. Namely, above the rock layer is soil that is directly exposed to erosion forces: water, wind, sun, etc., especially in the case of bare soil. Soil type was used as primary for the calculation of the g – parameter. Taking into consideration all the above, the original table was modified with a change of soil types according to WRB classification and including soil types missed in the original table. The classification of rock types is the same. For the calculation of the $[X_a]$ parameter, the CORNE LCU map was used. This map is on a scale near 1:100 000 and some polygons are large. The class broadleaved forest encompasses a forest area with a cover from 0.4 to 1.0 that is very wide. Because of that, we developed an additional level 4 for this class and changes in the table where this parameter for a forest with good cover is from 0.05-0.2 while for a forest with lower cover is 0.2-0.6. The class “transitional woodland and shrubs” with a value of 0.5-0.7 was added as well as the class lowland grasslands in the region vulnerable to desertification with a value of 0.85. The results of the modelling were compared with those got from the bathymetry of the reservoirs. For the central and eastern part

of the country EPM map show appropriate results. For the region of the western part of the country where the configuration is alpine, this approach shows lower values of erosion intensity and sediments. because the main sources of sediments there, origin form rockfalls, landslides, talus cones, streambank erosion, and deep gullies, which are dots or lines on the map on a small scale, and additional improvement is necessary. Map of erosion using the RUSLE method is suitable for agricultural land while in the mountains shows lower results. A map created using EPM is suitable for general planning but in the case of engineering designing purposes this map is only a basic map and in detail mapping and modelling are necessary to be a base for the right calculations of erosion intensity, produced and transported sediments, and designing erosion control measures.

Keywords: soil erosion, EPM, RUSLE

USE OF INEXPENSIVE UAV SYSTEMS FOR ENVIRONMENTAL APPLICATIONS

(CASE STUDIES REVIEW)

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Abstract: The emergence of low-cost UAV systems (drones) in recent times, brought into view the vast application of UAV into environmental applications. This paper presents the use of several drones and sensor types from the manufacturer DJI for several case studies. The first case study is in the vicinity of Skopje, Skopska Crna Gora Mountain. The use of a drone, in this case, is for detailed mapping of erosive processes and gully erosion in Strachinska Drezga torrent with Mavic pro drone. The main output of the mapping is an ortho photo image of the torrent and DTM. These inputs were used for the construction of anti-erosive works. The second case study is located in Georgia, Abkhazia. The main objective of the drone mapping mission is to develop a detailed DTM of the Gumista river and flooding area. The DTM will be used as an input for the development of an accurate two-dimensional hydraulic model of the river. The drone used in this case is equipped with RTK module (Phantom 4 RTK). The drone image acquisition is combined with ground control points acquired with GNSS RTK ground station for improving the accuracy of the output. The last case study involves the use of a visible and thermal camera on Mavic enterprise 2 advanced for mapping temperature differences of waste disposal sites.

Keywords: UAV, drone, DTM, DEM, ortho photo

EVALUATION OF VULNERABILITY TO SOIL EROSION USING GIS AND AHP CONSENSUS MODEL

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Abstract: Soil erosion is one of the threats to the conservation of soil and water resources. In order to evaluate the vulnerability of soil erosion in this study, it was used GIS and AHP consensus models. Solutions for evaluating vulnerability to soil erosion challenges frequently involve highly complex spatial decision-making processes that require the simultaneous use of several decision support tools such as Geographic Information Systems (GIS) and Multi-Criteria Decision Making (MCDM) techniques. The study was conducted on the mountain Fruška Gora in the Vojvodina province, the northern part of Serbia. The main factors of soil erosion include geomorphology, which focuses on the quantitative analysis of interconnected processes, pedology which is important for evaluating potential and actual soil erosion risk, slope which has an important influence in controlling erosion rates and CORINE land cover as the essential database for evaluating actual soil erosion risk. The results of this study were maps with the evaluation of vulnerability to soil erosion which served to determine discrete degrees of potential and actual risks, as well as their distribution. Besides, the results can provide the decision-makers with the areas with erosion risk so that they can develop general soil and water conservation plans and generate detailed erosion research for the areas of high erosion risk.

Keywords: Evaluation of vulnerability, Soil erosion, GIS, AHP

CHARACTERISTICS OF DYSTRIC CAMBISOL IN THE FOREST MANAGEMENT UNIT "LISINA"

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Abstract: Soils are an important natural resource and in the forestry sector represent a base for the separation of forest management classes and the preparation of planning documents. Identification of soil characteristics is the first step toward the estimation of ecological-production potential, but also for analysis of land degradation. The Lisina mountain is located in the southwestern part of the Republic of Srpska (western Bosnia and Herzegovina) with heterogenous soil cover. Soils are researched in the forest management unit "Lisina", sections 69 and 96/2 of forest management area "Mrkonjičko". A total of 2 soil profiles were analyzed along with basic genetic horizons. Moreover, the level of soil compaction as a result of mechanization impact has been analyzed. Two soil types are identified Cutanic Luvisol (Dystric) in section 69 and Haplic Cambisol (Dystric) in section 96/2. Soils formed on silicates are extremely susceptible to erosion because they are very permeable and have a low water capacity along with texture. Cutanic Luvisol (Dystric) has more favorable physical properties (greater depth), higher humus content, and degree of bases saturation while Haplic Cambisol (Dystric) has higher level nutrients (P₂O₅ and K₂O). The research aims to define characteristics of soils in approximately the same ecological condition, but with different types of vegetation, to determine the erosion risk under influence of forest mechanization.

Keywords: soil, dystric cambisol, physical and chemical properties, erosion risk

DRIPPING RAINFALL SIMULATORS DESIGN FOR SOIL RESEARCH

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Abstract: Dripping rainfall simulators (DRS) are important instruments in soil research. However, a large number of non-standardized simulators have been developed, making it difficult to combine and compare the results of different studies in which they were used. To overcome such a problem, it is necessary to become familiar with the design and performances of the current rainfall simulators applied. It has been conducted a search for scientific papers describing dripping rainfall simulators and papers that are thematically related to soil research using DRS. Simulator design analysis was performed integrally, for simulators with more than one dripper (DRS>1) and with one dripper (DRS=1). Descriptive and numerical data were separated from the papers and sorted by proposed categories, according to which the types and subtypes of used simulators are determined. The six groups of elements that simulators could consist of have been determined, as well as their characteristics, representation, and statistical analyses of their available numerical parameters. The characteristics of simulators are analyzed and presented, thus is facilitated the selection of simulators for future research. Description of future simulators in accordance with the basic groups of simulator elements should provide all data necessary for their easier replication and provide a step closer to the reduction of design diversification and standardization of rain simulators intended for soil research.

Keywords: dripping rainfall simulator, drippers, rainfall simulators review, soil research, rainfall simulator construction

EXPERIMENTAL RESEARCH OF SOIL RESISTANCE USING PORTABLE FIELD RAINFALL SIMULATOR

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Abstract: Degraded areas of forests, due to the action of erosion processes, have a reduced capacity to perform ecosystem services and a reduced production potential of wood mass. In order to achieve an appropriate solution for remediation, it is necessary to determine the elements of the mechanisms of erosion processes, by analyzing the physical and mechanical parameters of the soil. Experimental soil testing has conducted using a portable field rainfall simulator in the forest area in the gullies and the conditionally stable zone of the gullies' banks. It's been observed the effects of changes in soil moisture on changes in the mechanical parameters of the soil, as well as the formation of surface runoff and soil erosion. It was established that the change in the current soil moisture affects the change in the mechanical parameters of the soil. The values of soil shear resistance and resistance to penetration are lower in tests in gullies, compared to tests on gullies' banks. The presence of cracks and macropores influenced the appearance of rapid infiltration of part of the precipitation into the soil, which resulted in small amounts of runoff water on the exit profile (3.76-32.71% of the total volume of rain). Surface erosion occurs in the form of tearing off entire microaggregates and their transport via micro-furrows to the outlet profile. The soils of the research area are sensitive to erosion processes when they are in a state of low natural humidity. With an increase in humidity above 20%, the soil becomes more sensitive to erosion processes and other forms of physical degradation. After an increase in the current humidity above 42% (the average value of the liquid limit), the soil is in a saturated state when the resistance forces cease to act.

Keywords: soil experimental research, rainfall simulation, soil mechanics, soil erosion, soil resistance

WATEM/SEDEM VERIFICATION BY SOIL TRUNCATION METHOD

(MOSCOW REGION, RUSSIA)

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Abstract: The popularity of soil erosion modeling is growing rapidly. However, less attention is given to erosion model verification, which is mainly based on sediment yield estimates. Spatial model verifications are very few. In this study soil losses over 250 years (calculated by WATEM/SEDEM) have been verified by the soil truncation method on the site in the Moscow region, Russia. Just over 1,500 soil sampling points were analyzed in the area of 100 km². A clear tendency was revealed in the change in the proportion of non-eroded soils with an increase in the volume of calculated erosion losses: with losses <50 mm, the proportion of non-eroded soils was 87%; 50-100 mm 86%; 100-150 mm 81%; 150-200 mm 78%; 200-250 mm 70%; 250-300 mm 63%. 13% of points with losses <50 mm were diagnosed as weakly and moderately eroded soils. All such points are located nearby the multi-temporal borders of the arable land. This discrepancy is probably related to the inaccurate restoring the cropland boundaries. The relief and significant changes in the configuration of the cropland led to significant redeposition of sediments and the formation of a large area of warp and washed-warp soils. It remains unclear why non-eroded soils predominate even in areas with erosion losses >250 mm calculated by the model. There are two possible explanations: i) model calculations are universally overestimated; ii) plowing changed the soil-forming process and contributed to a change in the depth of the subsurface horizons of Umbric Albeluvisols.

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Keywords: soil erosion, modeling, WATEM/SEDEM

USING POLYMERS TO REDUCE WATER EROSION IN SOILS

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Abstract: Soil water erosion is the most common type of soil degradation, especially with rainfall or artificial irrigation. The degree of erosion impact strongly depends on the duration and intensity of irrigation, as well as the steepness of the slope and the particle size distribution of soils. Synthetic polymers began to be used in land reclamation since the 1950s as structural formers to reduce soil erosion. Polyacrylamide (PAM) has been shown to be a promising additive for preserving soil structure and soil aggregate strength, as well as for maintaining high infiltration and low surface runoff. The paper analyzes the degree of effectiveness of anionic polyacrylamide (“Gipan” preparation) on different types of soils (chernozem, sand, clay) for water erosion. The evaluation was carried out under laboratory conditions on the sprinkler system. The sprinkling rate corresponded to a heavy downpour (6-7 mm/min) and was conducted within 30 minutes after the start of runoff at slope angles of 3, 7, and 15 degrees. We found that the “Gipan” increases the flush onset time by about 5 minutes and decreases the amount of sediment material by 1.5 times at 3°, by 1.7 times at 7° and by 2.5 times at 15° for chernozem when using the polymer concentration recommended by the manufacturer. For sand at slope angles of 3° and 7°, flushing is reduced by 1.5 and 2.9 times, respectively, but the start time of flushing did not change at all concentrations. The amount of washed-out sediments at 15° increases by 1.1 times compared to the control, and the start time of flushing corresponds to the control. Clay shows an increase in flushing time at all angles by about 4-5 minutes, but the amount of washed-out substance increases compared to the control by 1.3 times at 3°, 1.1 times at 7° and decreases by 1.1 times only at 15° when using the polymer concentration recommended by the manufacturer.

Keywords: water erosion, soils, polymers, soil erosion reduction

APPLICATION OF THE RUSLE MODEL IN THE ASSESSMENT OF SOIL EROSION USING THE RCP 8.5 CLIMATE SCENARIO

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Abstract: Soil erosion is one of the most important contemporary problems of soil degradation and represents a threat to the functioning of urban areas, which was the reason for choosing the territory of the Master plan of Belgrade (Serbia) as the research area. The assessment of soil erosion loss was analyzed using the RUSLE (Revised Universal Soil Loss Equation) model, which belongs to the group of empirical models. Modeling as a scientific method is of great importance for understanding the process and analyzing the influence of endogenous and exogenous factors on the genesis, occurrence, and intensity of erosion processes, as well as for predicting the production of erosion material. The assessment of soil degradation was analyzed based on the current land cover and the application of simulations of changes in climate parameters according to the RCP8.5 climate scenario, which is expected for the middle of the 21st century (2046-2065). The aim of applying this methodology is reflected in the assessment of soil losses based on climate change, which is defined as the middle of the 21st century if there is no change in land cover for the observed future period.

Keywords: RUSLE, Soil erosion, Erosion model, Climate change, Land cover

SOIL EROSION RATES BASED ON ANATOMICAL CHANGES IN EXPOSED ROOTS –

CASE STUDY FROM SOUTH WEST BULGARIA

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Abstract: In recent years different methods for soil erosion assessment have been used. Because of its high accuracy in estimations, dendrogeomorphology was selected as one suitable and reliable scientific method to achieve the main goals of this study. The anatomical responses of the tree-rings of the roots have been used as proxy data to describe the denudation events. The study region is the watershed of the Sedelska River, South West Bulgaria. The watershed of the river is situated on the territory of one of the most affected by soil erosion regions in Bulgaria - The regional forestry directorate Blagoevgrad. Coniferous tree species (*Pinus nigra* Arn. and *Pinus sylvestris* L.) and broadleaves tree species (*Platanus orientalis* L. and *Quercus frainetto* Ten.) were studied. In total 30 trees were cored for dendrogeomorphological analysis. One sample from the root and one sample from the stem has been taken from each study tree. The annual tree-rings have been dated, cross-dated, and measured. Growth patterns were analyzed and denudation events were calculated.

Keywords: dendrogeomorphology, soil erosion, denudation events, Sedelska river

TOPIC 2
Torrential Floods
(Genesis, Impacts, Risk)

THE METHOD OF CRITICAL POINTS AS A TOOL FOR IDENTIFYING FLOOD RISKS IN THE CZECH REPUBLIC

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Abstract: The identification of critical points serves as an indicator of the possible risk of flooding from torrential rainfall. Critical points (CP) are determined in places where concentrated surface runoff caused by intense rainfall enters the built-up area from the catchment area. Knowledge of the existence of critical points enables the implementation of conservation preventive measures, evaluation of flood risk associated with the transport of sediment due to erosion processes, and improvement of management measures in respective catchment areas, even before an event occurs. Identification of such critical points offers a basis for an optimal new strategy of threat mitigation, via both organizational and structural measures in catchment areas. The content of the article is a proposal for the identification procedure of critical points and surfaces decisive in terms of the formation of concentrated surface runoff from torrential rainfall with adverse effects on the built-up area of municipalities. This is an approach that goes both ways to define critical places within the entire Czech Republic as starting material for the search for a suitable "national" strategy leading to the mitigation of threats, at the same time it is possible to use the output in forecasting practice and especially in the creation of flood and crisis plans and other proposals measure. The identification of CP presents a repeatable approach to identifying decisive areas in terms of the creation of concentrated surface runoff, with the aim of determining areas of land within built-up areas threatened by concentrated surface runoff and transport of sediment by storm rainfall. The results of this approach should primarily serve the needs of local councils of potentially affected areas as a basis for the formation of flood-prevention plans within spatial planning processes, and the proposal of conservation measures within land consolidation.

Keywords: critical points, concentrated surface runoff, mitigation of flood risks, conservation preventive measures

PRIORITIZATION OF TORRENTIAL FLOODS VULNERABLE WATERSHEDS UPSTREAM FROM THE “ROVNI” WATER RESERVOIR USING TOPSIS METHOD

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Abstract: Torrential floods are widespread natural hazards causing a lot of negative effects on people and the environment. During torrential floods, sediment transport increases leading to the deposition of sediment particles in the reservoir which decreases its storage capacity. Water reservoirs represent the most sensitive water management facilities to the erosion processes. Controlling sediment yield and sediment transport in the watershed is of great importance in extending the life of reservoirs, reducing potential economic damages, and supporting sustainable community development. The purpose of this paper is prioritization of sub-watersheds upstream from the “Rovni” water reservoir for conservation measures using the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method in order to extend the life of the reservoir. A total of 10 parameters were analyzed. Weights for each criterion (parameter) were calculated using the AHP (Analytic Hierarchy Process) method. The results showed that watersheds can be prioritized through geomorphological parameters complemented with land use for the selection of conservation measures. This will help decision-makers in better conservation planning of soil and water resources and thus in achieving sustainable development.

Keywords: soil erosion, torrential flood, water reservoir, TOPSIS, AHP

STUDY ON WATER RUNOFF AT ECOLOGICAL STATION “IGRALISHTE”

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Abstract: Climate change and its influence on ecological conditions led to changes in annual and monthly amounts of precipitations and also to a decrease in the ability of soils to deal with water quantities. In recent years floods caused by single rain became more and more common and for that reason studies of the ability of vegetation and soils to deal with the formation of a high quantity of water runoff are of great importance for undertaking appropriate actions for the mitigation of flooding risk. The study region is part of the territory of the Ecological station “Igralishte”, which is situated on one of the tributaries of the Sedelska river. The region is characterized by severe erosion processes in the past and specific ecological conditions that are prerequisites for significant water runoff. In the research, information from two experimental watersheds is used. The quantity of the annual and monthly runoff is determined and the quantity of precipitations is analyzed.

Keywords: water runoff, soil erosion, Sedelska river

GIS APPLICATION FOR HYDROLOGICAL FEATURES PREVIEW OF FLOODPLAIN FORESTS

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Abstract: Floodplain pedunculate oak forests in the alluvium of the river Sava are of great economic and ecological importance. Their growth and development features, and their survival, as well, mostly depend on available water quantity in the soil. The paper deals with the influence of groundwater levels on pedunculate oak forests' growth and survival in the floodplain forest zone. During three years long research determined an average (reference) groundwater level, and extreme – the wettest and the driest - year based on climate factors such as temperature and rainfalls. Deviation of an average from reference groundwater level in vegetation period during some years shows the possibility of risk zones presence. These zones are defined according to geostatistical analysis – ArcGIS, Kriging model and they are very significant for forest management because they can predict some drought events and warn forestry experts to react in time to prevent big damages. It should be said that the application of modern models contributes to a better understanding of the spatial distribution of groundwater which enables forming of risk zones depending on groundwater level fluctuation.

Keywords: ArcGIS, floodplain forests, groundwater level, risk zones

TOPIC 3

Prevention and Management of Soil Erosion and Torrential Floods

**THE INFLUENCE OF THE STRUCTURAL CHARACTERISTICS OF THE STAND
ON THE WATER REGIME ON THE EXAMPLE OF SCOTS PINE FOREST CULTURE
ON LIMESTONE IN SOUTHWESTERN BOSNIA**

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Abstract: The forest plays an important role in regulating the water regime, i.e., preventing the occurrence of torrential floods, which depends on the type of trees that make up the stand, the canopy, its age, and the structure of the stand. This paper examines the influence of the structural characteristics of the stand on the water regime, using the example of the plantation of scots pine (*Pinus sylvestris* L.) on limestone in southwestern Bosnia. An experimental plot (50x50m) was defined and surveyed in the subject plantation. In addition, rain gauges were installed in different conditions of the canopy, with which the amount of precipitation that reaches the surface of the forest ground was determined. Rain gauges were also placed on an open area close to the plantation. Research has shown that with an increase in the number of trees per hectare and a higher canopy of the stand, the retention of rainwater in the tree crowns increases by up to 30%. In a stand of scots pine, 720 trees per hectare were determined, while for the optimal interception, that number should be around 1400. However, an increase in the number of trees within the stand can have a negative impact on the stability of the stand. With a larger number of trees within the stand, the competition is greater, the trees dry out, the slenderness of the trees is higher, and the trees break or fall. Research has shown that silvicultural practices can achieve the same interception effect with a smaller number of trees per unit area if the cultivation interventions on care and thinning within the stand encourage better development of tree crowns. Vital trees with a well-developed crown have a root system with many root branches that permeate the soil, making it looser. Such forest soil, with a large proportion of macropores, can infiltrate and retain a significantly larger amount of rainwater than that on bare or agricultural land. This is especially important in the prevention of torrential flows that occur due to a large amount of precipitation in a short time. Research shows that the stand should be structurally built so that, in addition to the production function, it also plays an optimal role in preventing torrential floods and soil erosion. Stable multifunctional stands are only those that are regularly cared for, where tending measures and thinning optimize the composition of tree species, the number of trees per unit of area at a certain age, maintain the vitality of the stand, regulate the canopy of the stand, and increase the individual resistance of the trees within the stand.

Keywords: stability of the stand, water regime, torrential flows

**THE INFLUENCE OF THE FUNCTIONALITY OF WATER-PERMEABLE STRUCTURES
ON MOUNTAIN WATERCOURSES AND THE PRIMARY NETWORK
OF FOREST TRANSPORT INFRASTRUCTURE**

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Abstract: Bosnia and Herzegovina has a predominantly hilly-mountainous character, this, along with appropriate geological conditions, favors the creation of a dense hydrographic network. The hydrographic network represents a system of surface watercourses of an area, which appear constantly or periodically. Considering the large area covered by the economic units and considering the different natural conditions on the ground in the economic units, we encounter a very developed hydrographic network, which in many cases is intersected by the primary and secondary network of forest transport infrastructure. The riskiest positions when it comes to the negative influence of watercourses on erosion processes are the intersection points of forest transport infrastructure, rivers, and hill-mountain watercourses. In order to reduce the percentage of unusability of the primary network of forest transport infrastructure, it is necessary to approach quality solutions for surface water drainage as well as bridging existing mountain watercourses. Water erosion is one of the possible phenomena, which in some extreme cases can lead to the appearance of typical torrential flows, and occurs as a consequence of the negative effects of water flows. The aim of this paper is to analyze and determine the impact of the functionality of water-permeable structures on mountain watercourses and the primary network of forest transport infrastructure. For this purpose, research was conducted within the economic unit "Prusačka rijeka", which belongs to the forest management area "Gornjevrbaško". A total of 28 positions were analyzed, of which 13 were bridges and 15 were culverts. As part of the analysis of permeable structures, the assessment of the impact of the hydrographic network on the forest transport infrastructure at the points of their intersection, the damage and functionality of the permeable structures, as well as the erosion in the immediate vicinity of the culverts was processed.

Keywords: primary forest transport infrastructure network, hydrographic network, drainage facilities, land erosion

ON THE CONNECTION BETWEEN STANDARDIZATION AND SOIL EROSION AND PREVENTION OF FLASH FLOODS

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Abstract: With a very high degree of certainty, it is possible to state that today's humanity exists in an environment that generates various pressures on almost all elements of society. The intensity of emergency situations that threaten daily activities and social well-being is increasingly common due to a number of causes such as population growth (which increases the number of people potentially threatened in emergency situations), exploitation of natural resources (processes that often lead to an increase in soil erosion and flood occurrence), urbanization (which disrupts natural regulatory processes and increases exposure), etc. On the other hand, the parallel effects of climate change can only generate more pressure on natural and artificially created urban ecosystems, further burdening society. As a result, emergency situations caused by floods, wildfires, earthquakes, landslides, heat waves, and other natural disasters will only increase in number, which may lead to an increased volume of the loss of life, various disruptions in production lines, and an uncertain future. In this sense, and following certain global initiatives (like Sendai framework for disaster reduction, Agenda 2030, etc.), local self-governments and national regulatory bodies must be adequately prepared in order to minimize losses (of life, natural, and created values) in the event of such disasters. Having it in mind, system standards can be a very effective tool in the development of a response to the mentioned emergency situations either at the national or local level, because their application improves the quality of work, environmental protection, occupational safety and health, monitoring and operation of laboratories, communication, early warning, etc. Therefore, the goal of this work is to present the key components as well as the ways of applying various systems, and relevant standards for this area (primarily ISO 9001, 14001, 14031, 14090, 22328-1, 22370, 31000, 37101, 45001, etc.). The main conclusion of the paperwork is that an efficient, effective, and standardized system of response to emergency situations (as well as prediction and prevention) represents one of the key tools for the successful implementation of all measures within the so-called disaster management continuum. The key recommendation of the work refers to the strengthening of the suitable model for the future, more intensive application of adequate, standardized disaster management activities in this area.

Keywords: standardization, system standards, technical standards, conformity standards, prevention, management, soil erosion, torrential floods, resilience

IMPACT OF PROTECTIVE FOREST BELTS ON WIND SPEED REDUCTION AND AIR TEMPERATURE CHANGE, A CASE STUDY

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Abstract: The Protective Forest Belts (PFBs) are multifunctional objects that provide numerous ecosystem services and represent one of the most used agroforestry practices. Their primary function is wind speed reduction and consequently soil protection from wind erosion. Additionally, the PFBs in the zone of influence contribute to the microclimate conditions change. This study is performed in dominantly agriculture-oriented Pančevo municipality on the PFBs composed of *Juglans regia* and *Ulmus pumila*. The aim was to analyze the potential of PFBs to reduce wind speed and change the air temperature. The change in wind speed and temperature was detected by portable anemometers with logger (Lutron YK-2005AM Data Logger Anemometer) which are placed on a predefined transect (5H – upwind, and 3H, 6H, and 9H - downwind). The results show a high influence of PFBs in wind speed reduction. The highest reduction was detected in the first transect downwind (3H) with a reduction of 50% of incoming wind speed. Likewise, in the first transect downwind (3H), an increase in temperature of approximately 4 °C was detected. This change in microclimatic conditions near the belt (wind speed and air temperature) have a positive effect on soil conservation. Additionally, those changes lead to a change in evapotranspiration which further could positively affect agriculture production. The result of this research will increase the existing knowledge of PFBs as a multifunctional object in specific conditions of the research area.

Keywords: Protective Forest Belts (PFBs), agroforestry, wind speed reduction, air temperature change

MODELLING OF A TORRENT CHECK DAM IN THE DUBOKI POTOK BASIN

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Abstract: Transverse structures, as a method of watershed management, date back to ancient times, as evidenced by archeological records. The ongoing dramatic climate change has made them a pressing need. They are built to stop sediment transport, reduce the streambed slope, decrease flow velocity and direct the downstream in the middle of the flow to a normal position to prevent the overflow and flooding of a regulated river flow. The paper presents the step-by-step modeling of a check dam in the Duboki Potok basin in the municipality of Barajevo. The modeling was performed for each part individually: body (with sluices), dam wings, spillway (mouth), foundation (foot), and an apron made up of the paved section and bank walls, tooth, or fixation belt. The check dam parts were designed individually, by the given dimensions, and then integrated into the whole. Students of the Department of Environmental Engineering in the Protection of Soil and Water Resources at the Faculty of Forestry, University in Belgrade are taught modeling of 3D objects within the course in Descriptive geometry with Engineering Graphics. The course is aimed to help students develop spatial intelligence and skills, master creative model solving and designing, and learn how to perform and present specific tasks using the computer. Students master methods, skills, and software tools needed to create 3D objects. Powerful tools enable the allocation of materials and rendering of 3D models. The paper shows how the experience gained through the introduction of modeling increases students' understanding of space and spatial relationships through the modeling of a structure whose function can be seen in the field. After performing multiple examples and models, from the simple to the more complex ones, it was much easier for students to design 3D objects. The paper presents various materials and their use in the check dam design process (3D).

Keywords: Engineering graphics, 3D modeling, torrent check dam, software tools, AutoCAD

TOPIC 4
**Management of Sustainable Development
in Degraded Areas**

NATURE-BASED DISASTER RISK REDUCTION IN SERBIA

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Abstract: Serbia is highly exposed and vulnerable to natural hazards. The major natural hazards to which the country is exposed include torrential floods, storms, drought, landslides, earthquakes, hail, drought, fires, water and wind erosion. Floods and torrential floods are the most pervasive risks in Serbia, with about twelve thousand hazardous torrents. The most severe risk areas are the upper parts of the basins. There are many unmanaged and partially managed risk areas in the country, most notably in the upper watersheds of Likodra (Town of Krupanj) and Ljuboviđa (Town of Ljubovija), as well as the small town of Ljubovija in west Serbia, which is threatened by flooding of Drina and Ljuboviđa rivers. Wind erosion is a serious hazard that causes significant land degradation in agricultural areas of Vojvodina. Soil loss by wind erosion is in some cases similar to soil loss by water. Serbia has an established legal framework related to nature-based DRR. Relevant laws include The Law on Emergency Situations, Law on Fire Protection, Law on Health Protection, Law on Water, Law on Meteorological and Hydrological Activity, Law on the Republic Seismological Institute, Law on Forests, Law on Land Protection, and Law on Environmental Protection. Strategies relevant to nature-based DRR in Serbia include the Water Management Strategy, Biodiversity Strategy, Agriculture and Rural Development Strategy, Sustainable Urban Development Strategy, and the Strategy for railway, road, inland waterway, air and intermodal transport development. Other relevant documents include the Nationally Determined Contributions to the UNFCCC and the UNCCD National Action Program and Land Degradation Neutrality targets. Several relevant strategic documents are also in development, including the National Forest Program (GEF), the Draft Nature Protection Program of the Republic of Serbia (CBD, UNFCCC), and the Draft Low Carbon Development Strategy with Action Plan (GHG reduction). The main institution actors involved in DRR are the Ministry of Interior (The Sector for Emergency Management), Ministry of Agriculture and Environmental Protection (Agricultural Land Administration, Forest Service, Republic Water Directorate), Serbian Environmental Protection Agency (SEPA), and Local Self-Governments, Balkans Institute for Risk Assessment and Emergency Management (BIEM) and the Republic Hydrometeorological Services of Serbia (RHMSS). In 2013 the Serbian Government established the National Platform for Disaster Risk Reduction. There are several relevant initiatives in the fields of forestry, water, soil, and natural resources management projects in the country, including “Introduction of Innovative Management Planning in Forestry” (Gov. of Germany); “Preparation of the Water Management Information System for the Republic of Serbia” – WMIS (EU); “Increased Resilience to Respond to Emergency Situations” (Government of Japan); “Establishing the Conditions, the Level of Soil Pollution and Chemical Degradation of Soil in the Industrial Zone of Pančevo and Šabac and at the Fire Site on the Mount Tara” (Ministry of Agriculture, Forestry and Water Management); “Blue-green corridors (Belgrade, Serbia): mitigating natural hazards and restoration of urbanized areas” (Ministry of Environment), and “Strengthening capacities for implementation of international environmental agreements” (GEF).

Keywords: torrents, erosion, disaster, risk, reduction

**THE EVALUATION OF ECOSYSTEM SERVICES –
DEVELOPMENT OF THE METHODOLOGY IN SERBIA**

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Abstract: The sustainability of natural resources and environmental protection is the primary task of our community. The services of an ecosystem are the benefits that ecosystems provide to society. It covers the supply, regulation, and support services and culture. Ecosystem services are all kinds of benefits that humanity has from an established process system in the ecosystem. Ecosystem products are resources derived from ecosystems, and humans use them in a natural or altered form. They are vitally important for people's lives. In Serbia, this natural capital is neglected, and monitoring is barely present. Services that the ecosystem provides to a human are very difficult to value. To understand the effects that can be obtained from adequate management by nature, it is necessary to present them monetarily. Models have been developed that quantify and map the values of environmental services. Validating ecosystem services through the development of the methodology using the Invests model provides ecosystem management and involvement in the planning and decision-making process. The models are a spatially explicitly integrated modelling tool that quantifies changes in ecosystem services, e.g., different ways of using soil, the amount of carbon in the soil, and so on. Usually uses maps and tables on the resources, natural resource management in the function of environmental protection, for example, which can be combined with the economic data. By developing a methodology for the valorization of ecosystem services, mechanisms would be proposed, and actions are undertaken for possible monetary compensation of individual ecosystem services, as well as "penalties" due to degradation or inadequate soil management. The concept of sustainability is real, only if the company is ready to invest in the preservation and restoration of natural capital to maintain the ecosystem and its services.

Keywords: ecosystem services, benefit, models, sustainability, methodology

AN ECOSYSTEM APPROACH TO NATURAL RESOURCE MANAGEMENT:

CASE STUDY OF THE TOPČIDERSKA RIVER, SERBIA

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Abstract: Due to increasing demand, climate change, and world population growth, natural resources are getting exploited fast. One of the most important natural resources is soil, which is susceptible to degradation. Erosion as one of the forms of land degradation is also one of the most global environmental problems. Ecosystem services are often defined as benefits that nature provides to humankind. Soil, as the foundation of basic ecosystem functions, provides benefits to people, erosion control, water infiltration, food, fuel, fibers... This research is using the ecosystem approach as a strategy for natural resources management for promoting sustainability and conservation. The research was done in the Topčiderska River basin (Belgrade, Serbia). The InVEST Sediment Delivery Ratio model was used, to quantify erosion intensity, with a spatial distribution output map of overland sediment generation and delivery to the stream. InVEST SDR, a spatially explicit model is using a method based on the concept of hydrological connectivity and the (R)USLE model. This combined with socio-economic, law, and policy analysis gives a full set of information to decision-makers helping them to successfully manage and deliver sustainable ecosystems.

Keywords: ecosystem services, InVEST model, soil erosion, sustainability

APPLICATION OF SIMPLE ADDITIVE WEIGHTING METHOD FOR SELECTION OF APPROPRIATE MEASURES IN THE REHABILITATION OF THE LANDSLIDE

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Abstract: Changeable climatic conditions, a large amount of precipitation in a short period, as well as the complexity of the terrain structure can affect the occurrence of landslides in many areas. The paper deals with the problem of landslide rehabilitation on the regional road Stolice - Krupanj, which arose as a result of the steep slope, soil water saturation, and traffic loads. The technical measures for rehabilitating landslides that have been analyzed are: concrete retaining wall, gabion retaining wall, and geogrid. Slope stability analyses with applied technical measures were performed in the GEO5 program. All technical measures have increased the stability of the slope. The final decision about the appropriate solution was made after ranking all alternatives and applying the Simple Additive Weighting (SAW) method. This Multi-criteria decision analysis method is used to find the sum of the weighted performance rating for each alternative on all criteria. The criteria used for the analysis are: C1 – Construction costs, C2 – Fitting into the environment, C3 – Lifetime of the object, C4 – Susceptibility to damage. The application of the SAW method also requires determining the weight of the criteria and for this was used Rank sum method. As a result of the application of the multi-criteria decision analysis method, the use of geogrid proved to be the best solution to prevent damage caused by landslides.

Keywords: landslide rehabilitation, simple additive weighting method, multi-criteria analyses, slope stability

INTEGRATED WATERSHED MANAGEMENT – TRENDS AND PERSPECTIVES

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Abstract: Integrated watershed management has gained increasing importance in recent years, given its ecological, economic, and social importance. In order for watershed management to be in accordance with these principles, and at the same time efficient, it is necessary to analyze and integrate a number of different factors. This literature review determines the research trend of integrated watershed management with the aim of unifying thematic entities closely related to watershed management. 13 thematic categories have been determined in this field (decision-making, water resources management, agricultural watershed, stakeholders, legislation, habitat and biodiversity, climate change, cost management, and risk analysis, soil management, tourism, natural hazards, livelihoods, and ecosystem services). The synthesis of the results obtained by reviewing trends in scientific research in the mentioned area can serve as a significant basis for the organization and planning of integrated watershed management. In order to achieve the synthesis of the previously mentioned factors, close cooperation of the respective participants, who come from different fields, is necessary. This collaborative approach will potentially succeed only if the parties involved are committed to it. Such commitment should be built on an understanding of the problems and needs recognized by all parties involved. In addition, it is important to establish the decision makers who can influence the approaches and strategies, considering that their commitment to this approach is of particular importance.

Keywords: integrated watershed management, decision-making, water resources, soil resources, land management, natural hazards, erosion, stakeholders

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