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Summary

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Another kind of mountains: seamounts

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Abstract. Some of the most prominent features on the earth surface are the mountain ranges, but, under the sea surface, an entire new universe is worth to be studied. In this article, seamounts around the world are examined in a first attempt to classify them from the point of view of their geodynamical relevance. A special attention will be given to the seamounts positioned in the vicinity of subduction zones. This classification will be used later for numerical modeling their behavior once these seamounts enter into subduction. Also, the present state-of-the-art of the seamounts related knowledge is briefly presented.

Keywords: *seamounts, geodynamical perspective, subduction zone*

1. INTRODUCTION

Humans have been always fascinated with heights. In every culture around the world, the mountains were seen as gods and goddesses and they inspired many legends. Fiercer they were, the better. For Greeks, mount Olympus was not only one of the tallest mountains in Europe with its impressive 16 peaks, but also was the center of the Universe and the house of Gods (Fox, 1994). In Mexico, Popocatepetl (The Smoking Mountain) and Iztacihuatl (The Sleeping Woman) volcanoes inspired beautiful legends first written down by Pittman (1954), a scholar in nahuatl dialect. In Romania, almost every mountain peak from the Carpathians has a legend and fantastic stories transmitted from generation to generation, marking the connection between humans and the surrounding geography (Densusianu, 1910; Eliade, 1978; Coatu, 1986). Later, humans climbed, measured, classified and tried to conquer them. Sometime they succeeded, sometimes they failed, but this continuous enchantment remained. Nowadays, the mountains continue to be our ultimate fascination and many questions arouse: How did they form? What is their composition, their uplift or erosional rates? Are they volcanoes, or a product of compressional forces? etc. Anyhow, they can be observed and explored easily. When we talk about the longest mountain range, we usually think immediately at the Andean Mountain Range or the Andean Cordillera, as it is known (aprox 7000 km in length). When we talk about the tallest mountain peak, we immediately think about the Mount Everest with its official height of 8848 m, even though the latest estimation gives a value of 8844 m. But, we have to mention that this is the height measured above the sea level. What is the result when we eliminate completely the seawater? The answer is quite simple, as seen in Figure 1: the undersea features seem to be by far better represented and the bathymetric map unravels all the amazing structures under the sea level. Some of these features represent divergent tectonic plate margins. One example is the Mid-Atlantic Cordillera or Ridge considered the largest mountain range (aprox. 16000 km) on Earth. It extends from the Arctic Ocean to near the southern tip of Africa. At this constructive plate boundary, new oceanic crust is generated each year at a spreading rate of about 2.5 cm/yr. Other features represent convergent margins, where the oceanic plates are consumed and recycled by the subduction factory (Tatsumi, 2005, Hacker et al., 2003a,b). In these regions, known as subduction zones, the trenches can reach staggering depths down to almost 11 km as measured in the planet's deepest point, the Challenger Deep situated in the Pacific Ocean's Mariana Trench (Stern et al 2003). In the latest expedition lead by Victor Vescovo, in 2019, the DSV Limiting Factor submarine dived down to 10,927 meters with almost 16 m lower than the previous descent in the trenches in 1960 (Morelle, 2019). The divergent and the convergent margins are only some of the main features, which can be spotted on the main bathymetric map. The others are the continental shelf, the continental slope, the continental rise, the abyss and the abyssal plain, the volcanic island arcs and off course, the seamounts and guyots (Fig. 1). Also, when an oceanic plate subducts, in the trench region, there is a sedimentary prism, formed by pelagic sediments. Its presence and thickness and whether or not tectonic erosion, sediment accretion or sediment subduction is taking place, will depend a lot on the tectonic regime and plate velocities.

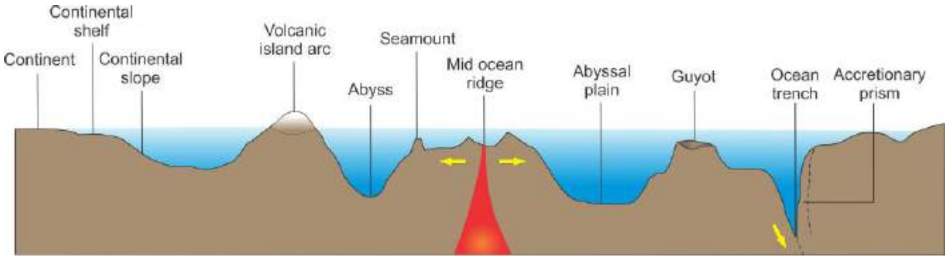

***Figure 1** Main features of the ocean floor: continental shelf (1), continental slope (2), continental rise (3), mid-ocean ridge (4), ocean trench (5), volcanic island arc (6), abyss (7), abyssal plain (8), guyot (9), and seamount (10).*

2. SEAMOUNTS AND GUYOTS: GENERAL CONSIDERATIONS

As can be observed in Fig. 2, the ocean floor is sprinkled with thousands of seamounts and guyots. In 2011, Kim and Wessel made the first seamount census, presenting a list of more than 25000 potential seamounts. The database, referred to as KWSMTS v0.1 was generated based on the vertical gravity gradient VGG grid v16.1. (Fig. 2).

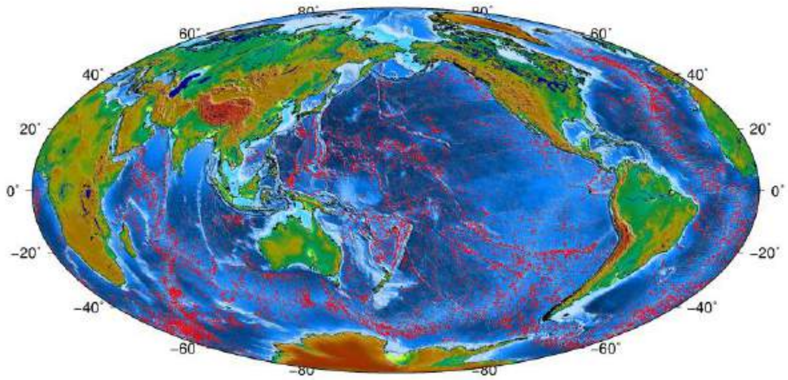

***Figure 2** Seamounts global distribution. Red dots represent more than 24,500 potential seamounts from the entire ocean basins (Kim and Wessel, 2011). Topography/bathymetry 1 minute data from Smith and Sandwell (1997) were plotted in Hammer projection, using GMT (Generic Mapping Tools) software v. 5.4.3. (Wessel and Smith, 1991, 1995, 1998)*

By definition, a seamount (Fig. 3) is a large submarine volcanic mountain or any protuberance rising at least 1000 m above the surrounding ocean floor (Encyclopedia Britannica). Generally, a seamount is made of basalt, and its summit and flanks are covered in with marine sediment. Most of the seamounts are formed near mid-ocean ridges. Sometimes they can appear in the vicinity of mantle plumes or island arcs. The 3-D geometrical structure can vary from perfect cones to complex shapes (Straudigal & Clouge, 2010).

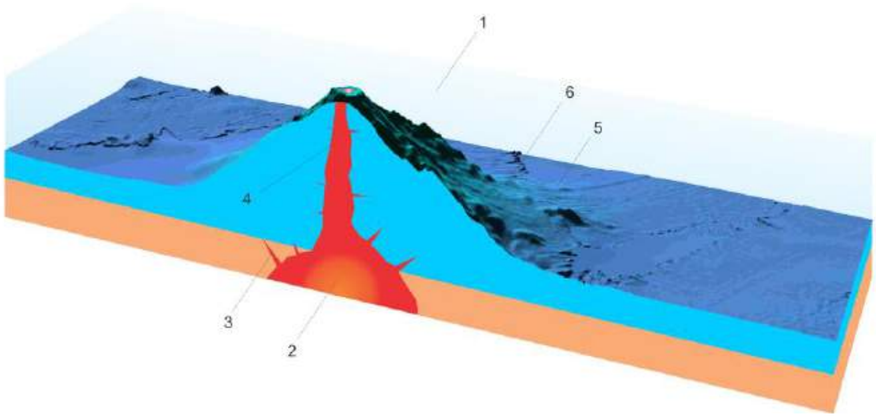

Figure 3 *Diagram of a submarine seamount structure. (keys: 1. Water 2. Magma chamber 3. Dike 4. Magma conduit 5. Pillow lava 6. Lava flow.*

A guyot, known in marine geology as a tablemount, is an isolated seamount of volcanic origin, with a flat top with diameters sometimes greater than 10 km (Fig. 4). They are found mainly in the Pacific Ocean, but sometimes they can be found in the Atlantic Ocean, too. They were first discovered by Harry Hess in 1945 and named after the American geologist Arnold Henry Guyot. They form at the ridge and then are shortened by atmospheric and/or wave erosion, by the time they migrate with the oceanic plate farther from the ridge.

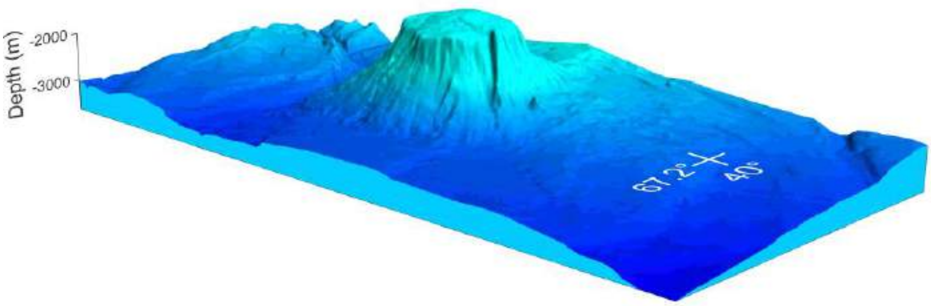

Figure 4 *The Bear guyot or tablemount. Seamount DEM is created using Global Multi-Resolution Topography (GMRT) data source (Ryan et al., 2009).*

These structures are the least explored morphological features and less than 0.1% were discovered using direct methods as echosounding or sampling through dragging, for instance. Most of the previously uncharted seamounts were discovered using indirect methods as the above-mentioned method of Kim and Wessel *(*2011), based on satellite observations.

Some interesting data regarding the seamounts are related to their measurements. The Hawaiian-Emperor chain of 80 Ma is considered the largest volcanic islands arc, with 6000 km length. From all the seamounts, Mauna Kea, which form part of the Hawai'i Emperor seamount chain, is the highest, with 4207 m above sea level and with a total height of 10100 m, topping the Everest by far.

3. SEAMOUNTS: GEODYNAMICAL RELEVANCE

Observing the seamounts distribution on the ocean floor, it looks like they form patterns, frosting into the oceanic crust past movements. Some of them are as old as approximately 180-200 Ma, and generally found in the west Pacific and north-west Atlantic (Müller, 2008), but others are even almost 270 Ma up to 340 Ma and located in the eastern Mediterranean Sea (Granot, 2016), as a remnant of the Tethys Ocean.

In one of the most dramatic examples, the Hawaiian-Emperor chain bends almost 60º, and the explanation is an abrupt change in the motion of the Pacific Plate 47 Ma ago and/or a southward drift of the mantle plume continuously providing material to the chain (Torsvik et al., 2017). Both processes seem to have played an important geodynamic role and have to be considered together.

Even though they are formed near mid-ocean ridges or in the vicinity of mantle plumes or island arcs, sooner or later, the fate of the seamounts or guyots is inevitable: they will end up entering subduction and being recycled into the subduction factory (Hacker et al., 2003a). They are processed into magmas, which will erupt later through volcanism, generating continental crust, all this recycling process being of the outmost importance for the evolution of the solid Earth (Tatsumi, 2005). In a subduction factory, the correlation between the location of intermediate-depth earthquakes, the depth of low-velocity subducted crust, and the predicted location of hydrous minerals, was already established through numerical modelling, as the dehydration reactions are linked to intermediate-depth seismicity (Hacker et al., 2003b, Manea et al., 2004). On top of this, it is possible that the presence of seamounts or guyouts on the subducting plate will add further complications to the already complex subduction systems (Scholz and Small, 1997).

Once nearing the subduction system, the influence of seamounts commences. As Watts et al. (2015) observed, a seamount, once it enters a subduction zone, will affect the forearc morphology, the uplift history of the island arc, including the structure of the downgoing slab. Sometimes the seamounts can be accreted to the forearc or carried down into the subduction zone and recycled, maybe due to the tectonic regime specific for each subduction zone in particular. The accretionary wedge is deformed in many cases. Sometimes, the seamount will collapse and if an abyssal fault is reactivated at the trench, the seamount can be even parted in halves. The subduction of a seamount/guyout can have mechanical consequences with a special emphasis on the generation of large earthquakes. In 1976, Kelleher and McCann, concluded that the collision zone in which the seamounts subducts, there is an boosting effect on the seismic coupling (Scholz and Small, 1997). This is a direct consequence of the subduction of large seamounts that possibly increases locally the normal stress across the subduction interface.

The importance of studying the seamounts behavior in any stage of their development is related generally with the geological hazards generated: major explosive eruptions, large scale landslides generating tsunami or large earthquakes.

1st of April, 2014, was an important year, as a Mw 8.1 earthquake occurred in Iquique, rupturing an important portion of a seismic gap in northern Chile. Geersen et al. (2015) by analyzing the marine seismic reflection and swath bathymetric data observed that several under-thrusting seamounts correlate well with the limits of the seismic rupture. They linked the subduction of those seamounts to the reduced plate-coupling, by fracturing the overriding plate in the shallow subduction zone. The authors agree that the subducting seamounts control intermediate coupling and seismic rupture.

Sometimes, a segment of the subducted slab is dominated even by a 40% of seamounts, as it was observed in central Costa Rica (von Huene et al., 1995). The seamounts entering subduction generally mark furrows and domes on the continental slope (Ranero and von Huene, 2000; von Huene et al., 1995). Using 3-D P-wave velocity structure and petrological modelling, Husen et al. (2003) analyzed the Costa Rica subduction zone, and through tomographic imaging within the seamount-dominated segment of the Cocos Plate they show that the structure is quite complex and a cluster of seismicity is associated to each of the anomalies. Interestingly, there was no sign of subducted seamounts at greater depths. As a seamount is formed mainly from highly altered, possible serpentinized and fractured oceanic crust, once subducted the buoyant mass will increase the normal stress, hence the occurrence of large subduction earthqukes (Cloos, 1992; Husen et al., 2002). Husen et al. (2003) conclude that by increasing the normal stress, it is possible also to reactivate the fractures associated with the formation of seamounts, producing a cluster of much smaller earthquakes in the vicinity of a subducted seamount.

In a recent study, Baillard et al. (2018) show that it is possible to track subducted ridges inside a subduction zone using the intermediate-depth seismicity. By looking at the distribution of intermediate-depth seismicity they conclude that the uneven distribution of this kind of seismicity, and the presence of a seismic gap, previously related to a supposed tear in the slab, may be instead directly related to the subduction of a ridge. Also, Morton et al. (2018) analyzed a cluster of events detected by an amphibious seismic network in Cascadia and they detected two separate clusters of events, one near a subducted seamount, and the second one probably by an accreted seamount. They concluded that the earthquakes detected recently in the Cascadia Subduction zone are related both, to the subduction of seamounts and a deformed upper plate.

Other possible consequences of seamounts subduction are spatially related to slow slip and tremor occurrence, as it was shown by Barker et al. (2018) for the North Hikurangi Subduction zone, in New Zeeland. Slow slip events, or SSEs, are slow displacement episodes that can have durations up to several weeks or months. In New Zeeland, they discovered a subducted seamount covered in sediments, which triggered slowslip events only where the sediments were present, and not on the top of the subducted seamount. Also they proposed that the high fluid pressure within the subducted sediments might facilitate shallow slow slip. Recently, Bonnet et al. (2019) showed that when a seamount enters a subduction zone and maintains its integrity down to ~30 km depth seamount does not behave as a large earthquake asperity but rather as a barrier.

The seamounts subduction, in regions where large seamount chains enter into subduction, can slow down even the mantle flow beneath the volcanic arcs, as was shown by Timm et al. (2013) in their work related to the subduction of the Louisville seamount chain beneath the central Tonga-Kermandec arc.

These represent only some key examples of the extensive research on seamount subduction. They clearly show that the presence of a singular seamount, or of many seamounts grouped in clusters or trails, will have a key influence on the long-term behavior of subduction zones. Seamounts can distort Wadatti-Beniof zones and also strongly affect the degree of mantle wedge hydration and the oceanic crust at least down to intermediate depths. Additionally, an important influence was observed even further down, where the mantle flow can be influenced locally by the subduction of these features.

4. SEAMOUNT SUBDUCTION: ANALOGUE EXPERIMENTS

Analogue experiments were performed in order to elucidate the fate of seamounts entering subduction and their possible implications on the mechanical behavior of the subduction zone. Researchers were interested mostly in the deformation patterns observed. Usually, the analogue models, will analyze the complex fracture network, taking into account a brittle/plastic rheology (Dominguez et al., 1998b, Wang and Bilek, 2011). Most of these experiments are based on classical sandbox modeling, in which the spatial-temporal deformation is compared with seismic images and bathymetry interpretation. Various authors tried to analogue modeling the subduction of a single seamount or plateau. They observed that the trench remained quasi-linear on each side of the plateau in the models with a stronger slab, but also some severe deformation at the front of the overriding plate, where seamounts or aseismic ridges subduct (Domingues et al., 1998b, 2000; Martinod et al., 2005). Sometimes the authors considered small conical-shape seamounts or guyots, other times trails of seamounts, but the accretion of seamounts was avoided. However, they were able to obtain a good correlation between the marine data and their experimental results, after a comparison with the well-studied Costa Rican seamount subduction zone. Beside the preferred setup where seamounts are perpendicular to the trench, the impact of oblique subduction of seafloor irregularities was also performed, with satisfying results (Dominguez et al., 1998a, Hampel et al., 2004, Zeumann and Hampel, 2015).

Recent analogue experiments (Wang at al., 2019) had a different approach and the attention was focused on the effect of seamount trails on the accretionary wedge in order to understand the deformation mechanisms affecting it.

Anyhow, the main disadvantage of analogue modeling is related to the fact that thermal conditions cannot be imposed inside the sandbox, and from here, the necessity to consider other advanced modeling methods.

5. SEAMOUNT SUBDUCTION: NUMERICAL MODELS

As technology became more sophisticated, researchers tried to model numerically the seamount subduction and the possible implications resulting from this process. Those numerical models showed influence that a bathymetric height can have in a subduction zone, especially on the overriding plate: mineralization processes in the overriding plate, as shown in a 1-D model by Rosenbaum et al. (2005); uplift of the overriding plate, augmented subduction erosion and decrease in magma production, as in the 2-D models by Gerya et al., (2009); rotation of the overriding plate as in the 3-D models of Wallace et al. (2009). Some unsolved issues, were answered by Mason et al. (2010), when they performed 3-D numerical models in which revealed that the impact of buoyant oceanic plateau with a subduction zone may alter the trench behavior, regardless the slab and plateau rheology.

In recent years, Ruh et al. (2016) used advanced 3-D numerical techniques to investigate the evolution of crustal deformation and stress distribution within the upper plate induced by the underthrusting of subducting seamounts. The dynamical effects of the upper plate strength, subduction interface strength, and strain weakening of the crust are investigated. Results of numerical experiments are consistent with seismic reflection images and seismic velocity models of the upper plate in areas of seamount subduction along the Middle America Trench and give important insights into the long-lasting question, whether subducting seamounts and rough seafloor act as barriers or asperities for megathrust earthquakes. However, these were mechanical models, without including the equation of energy, of heat transport, in the modeling. Last year, during the International Joint Workshop on Slow Earthquakes held in Fukuoka, Japan and the Latin America Academic Conference organized in Nikko, Japan, Manea (2018 a,b) showed for the first time 3-D numeric modeling results that incorporate both the mechanical and the thermal effects of seamount subduction. While this is work in progress, the preliminary results revealed that seamount subduction could produce significant temperature changes along the seismogenic interface, with implications for subduction earthquakes of paramount importance.

6. SEAMOUNTS CLASSIFICATION

Most studies tried to classify the seamounts for their biological importance (Clark et al., 2011) or from the mineral resources exploitation point of view (ISA, 2007), but here, the seamounts around the world are examined in a first attempt to classify them from their geodynamic relevance point of view. A special attention is given to the seamounts situated near subduction zones. This classification will be used later for numerical modeling their behavior once they enter into a subduction zone.

Straudigal & Clouge (2010) consider that there are six main types of seamounts based on their geological evolution: small seamounts (100–1000-m height), mid-sized seamounts (>1000-m height, > 700-m eruption depth), explosive seamounts (< 700-m eruption depth), ocean islands, extinct seamounts, and subducting seamounts. From the geodynamical point of view, the subducting seamounts are of upmost importance (Fig. 5).

As we classify seamounts entering subduction using their density on the subducted oceanic plate, their size and their integrity criterions (Fig. 6), another criteria which has to be taken into account is related to the existence of a root, and whether or not that root is serpentinized.

Also, it is important to consider if a seamount complex is affected by hydrothermal circulation. Based on this, some of them are considered hot and others cold, and heat production approximations in conjunction with heat flow observations will be used for better constrain the numeric models (Fig. 7).

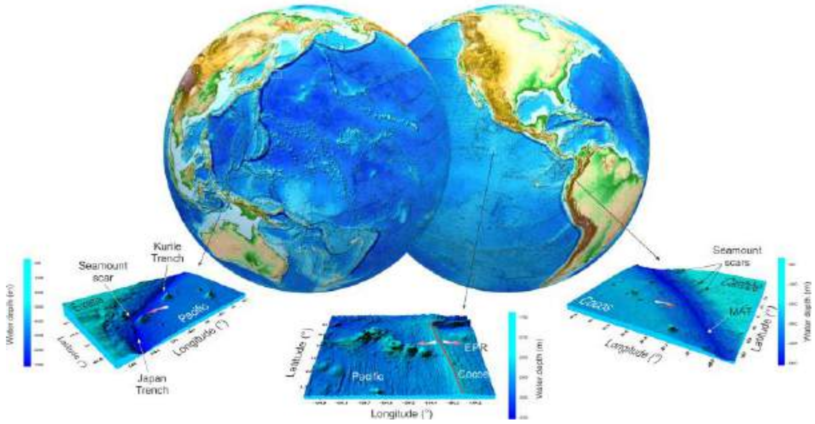

Figure 5 *Top: Pacific and North America view angles of color-shaded global bathymetry and topography maps (ETOPO1 Global Relief Model dataset, Amante and Eakins (2009)). This figure was created with the open source software ParaView (http://www.paraview.org) version 5.6.0, licensed under the CC BY 4.0 license (https://creativecommons.org/licenses/by/4.0/).*
Bottom: Three seamount regions are shown in detail corresponding to Japan and Kurile subduction zones, East Pacific Rise (EPR), and Middle America Trench (MAT). Red arrows show the movement of tectonic plates. Red curve corresponds to the location of EPR. Maps are created using global multi-resolution topography-bathymetry data from Ryan et al. (2009).

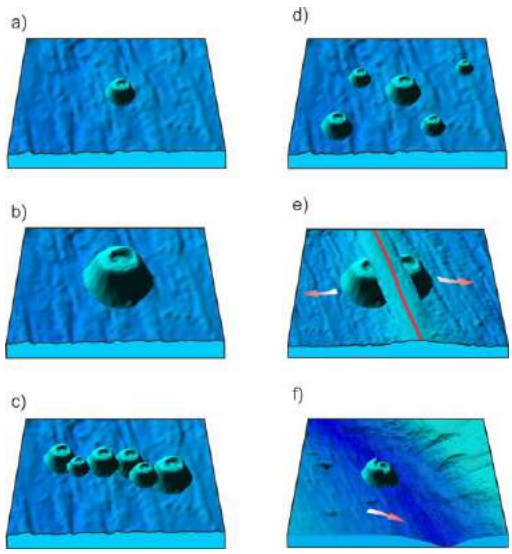

Figure 6 *Different types of seamounts: a) Isolated single small and medium-size seamounts. b) Isolated single large-size seamounts. c) Seamount chains. d) Clusters of seamounts of different sizes. e) Seamount split in two by a spreading ridge (thick red line) f) Faulted seamount approaching a subduction zone.*

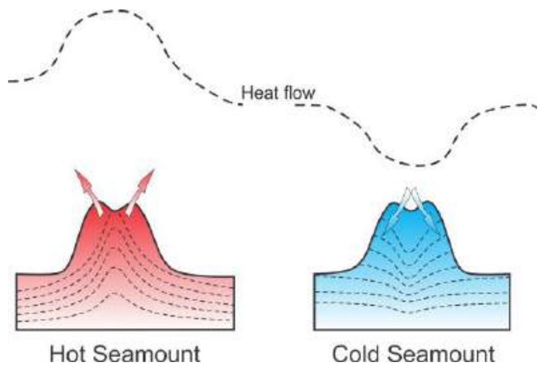

Figure 7 *Seamounts temperature distribution as a function of hydrothermal circulation. Hot seamount refers to a seamount with an outflow water circulation. Cold seamount refers to a recharging seamount. Dashed curves inside the seamounts refer to hypothetical geotherms. Curved arrows show the water flow. Dashed curves add noted with "heat flow" show a theoretical heat flow distribution.*

7. CONCLUSIONS

There is an obvious advantage of performing a complex thermomechanical numerical modeling in order to understand the seamounts behavior. This is an initial effort to understand the long-term effect of seamount entering into subduction, but also serves for further advancing our understanding of oceanic plate irregularities impact on active subduction zones.

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Comparative analysis of disaster risk management practices in Bucharest, Ciudad de Mexico and Istanbul

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Abstract: Natural disasters represent a major problem for many big cities. The biggest part of the population is in cities, which makes the concept of urban planning be a significant problem for the decision makers. In this paper, there are presented the results of a comparative analysis of the disaster risk management practices between Bucharest and Ciudad de Mexico in South America; and Istanbul in the euro-Mediterranean region. The analysis shows that all three cities have made considerable efforts regarding the risk analysis, especially in earthquakes. The elements they took into consideration are: the political engagement, identifying risks, the institutions and managing knowledge. Finally, the papers concludes by reasoning that the local authorities must focus more on reducing risks in order to reduce the physical vulnerability and to reach urban durability.

Keywords: disaster risk management, urban hazard risk, urban sustainability, geospatial information systems (GIS), earthquakes, vulnerability.

1. Introduction

Natural disasters were associated in the past with rural populations and poor countries (Mitchell, 1999a). But as the world's population continues to move to urban areas (Ghajari et al., 2017), cities are facing a high risk of natural and anthropic disasters (Sennewald, 2016).

Vulnerability in case of disasters is higher today than in the past as a result of population growth, the number and complexity of buildings, services and infrastructure in a city (Ilkisik et al., 2010). Thus, very large cities begin to be affected by disasters in ways that challenge available scientific knowledge and existing management institutions (Mitchell, 1999b). The economic and human losses caused by natural hazards are influenced by the quality of urban management and exacerbated by the lack of urban expansion planning (World Bank, 2011). Economic damages produced annually globally are of several billion dollars (Guha-Sapir and et al., 2011). This estimate takes into account the effects of physical damage on the built environment, the cost of care for the population and economic losses (Walker et al., 2014). Unless action is taken to identify and manage the risks of disasters, the resulting losses will have serious implications for the safety, quality of life and economic performance of cities (World Bank, 2011).

Identifying potential risks and developing urban vulnerability reduction plans are key to achieving urban sustainability (Li et al., 2016; Sharifi, 2016). Cities can better plan and respond if the location and nature of risk is known and also if risk assessment and management processes are integrated into urban management and development programs (World Bank, 2011).

Risk management must identify urban vulnerability and suggest measures to reduce it (Cardona, 2005). The vulnerability of the population to an earthquake or other disaster depends on the combination of factors that directly affect them (e.g. structural damage and access to trauma centres) and indirect (e.g. socio-economic disadvantage) (Rygel et al., 2006, Flanagan et al., Fekete 2012; Smith 2013, Ghajari et al., 2017). And, urban vulnerability is the degree of damage to a city's components (Brooks, 2003).

Risk management plans have four stages: risk reduction, training, response and recovery (World Bank, 2011). Risk management is an integral part of urban crisis management (Cervelli et al., 2016) and many studies have been undertaken on the application of GIS in crisis management and modelling under different risk conditions (Armaş and Radulian, 2014; Nejad et al., 2015; Zhao and Liu, 2016; Khamespanah et al., 2016). Thus, GIS-based decision analysis techniques have been used in disaster assessment, risk prioritisation and land use planning (Ghajari et al., 2017).

The present study builds on existing research demonstrating how natural hazards pose threats to the safety of the population. For example, earthquakes have been major natural hazards since the last century in major cities: Tokyo, Los Angeles, San Francisco, Mexico City, Lima, Istanbul and Bucharest (Mitchell, 1999b; Mitchell, 1999c; Gheorghe and Armaş and Gheorghe, 2015).

This study aims to analyse disaster prevention / reduction plans in Bucharest and other two major cities: Istanbul and Ciudad de Mexico. We chose these two cities due to the presence of the metro line, the fact that they are cities with a high population and the high potential for a seismic occurrence (Fig. 1).

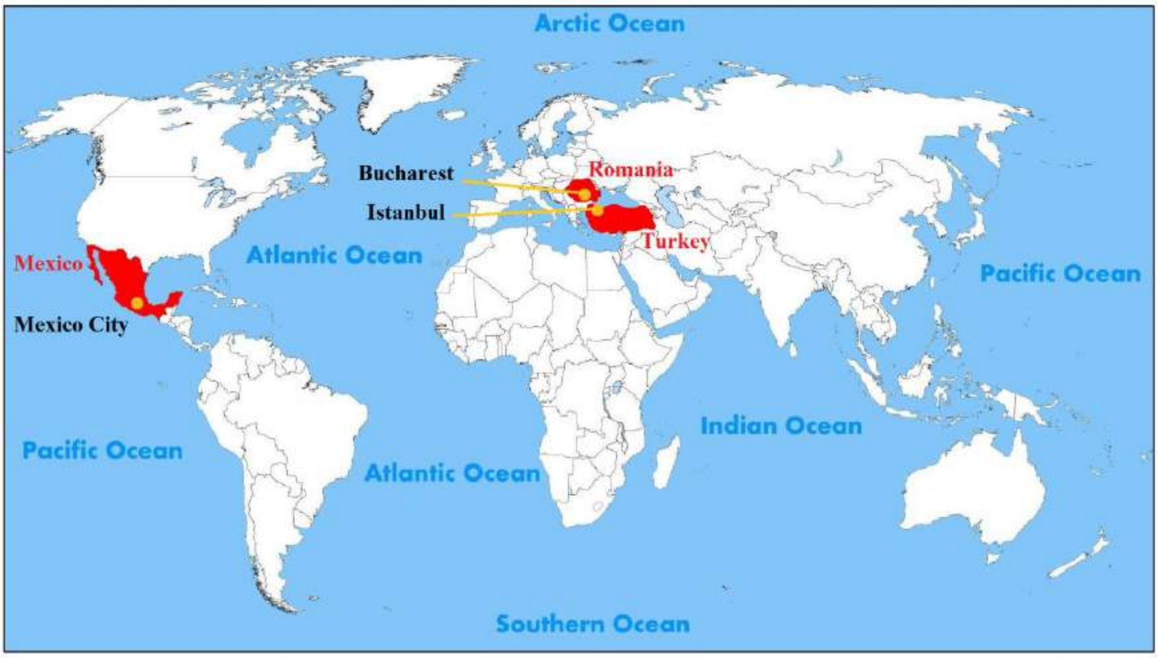

Figure 1. *Location of the Bucharest, Mexico City and Istanbul cities*

2. Approaches to urban risk management and planning

Urban risk assessment is ideally carried out as part of a cyclic risk assessment process, development and implementation of a risk management plan and monitoring of progress in risk reduction (World Bank, 2011). However, the most widespread form of public or private service is the planning of post-disaster reconstruction activities in urban areas (Spangle, 1991). Although the potential role of urban planning in reducing earthquake damage is often mentioned, the number of cases of plans or implementations in this area is very rare (Balamir, 2004).

The disaster preparation plan has the following elements: hazard identification; assessment of areas and critical activities (industries, infrastructure); loss estimation (economic modelling); establishing the optimal reduction strategy; risk reduction (microzonation, early warning); preparing the response team; communication and education (World Bank, 2018).

2.1. Seismic risk management and planning in Istanbul city

The city of Istanbul has been an important centre in the social, economic, geopolitical, commercial and cultural spheres for at least two millennia. Although Istanbul is a very old city, it grew very fast, especially after the 1950s. Thus, its population increased from 1 million (in the 1950s) to 12 million (Ilkisik et al., 2010). And, the number of buildings has reached about 1,300,000 (Nilay et al., 2019). Istanbul and its surroundings are the settlements that have been affected by many earthquakes throughout history. Historical records for the past 2000 years (Ambrayses, 2002) statistically reveal the re-emergence of a destructive earthquake that strikes Istanbul every century (Nilay and colab., 2019). The last two major seismic events that took place in eastern Marmara in 1999 are the earthquakes from Kocaeli and Dâmbătă. Although Istanbul is 90 km from the epicenter of these earthquakes, the damage to many buildings and the loss of life were great (Ersoy and Koçak, 2015).

Istanbul's problems with seismic risk range from the poor technical quality of buildings to uncontrolled urban growth and an inflexible planning system that remains incompatible with city dynamics (Ilkisik et al., 2010). The JICA study (2002) estimated that a major earthquake of Mw = 7.4 near Istanbul could cost more than 50,000 lives and cause economic losses of more than 60-70 billion dollars. A study performed by the Construction Chamber (2005), which is based on 1278 buildings (0.1% of the total) in different locations in Istanbul, indicates a medium quality of concrete (Nilay and colab., 2019). The high seismic potential of North-Anatolian Plates (NAF) in the Sea of Marmara poses a great risk to Istanbul (Ersoy and Koçak, 2015). Also the construction of the metro tunnels between Taksim and Yenikapi caused damage to a building in the French consulate (Seeley, 2001).

In view of these risks, the Istanbul Metropolitan Municipality runs a micro-zoning project in the south-western part of the city and has recently set up the Disaster Coordination Centre (AKOM) to improve preparation and seek reduction and prevention options (Fernandez et al., 2019; Nilay et al., 2019). Studies on "Istanbul's earthquake risk assessment" and finding suitable solutions for complex "risk reduction" issues, "Istanbul's General Earthquake Plan (EMPI)" was commissioned by the Istanbul metropolitan municipality (IMM) to a consortium that involves four universities in Turkey. The EMPI was completed in 2003 and identified 13 risk sectors. Implementation of the EMPI was done in the Zeytinburnu district, which was determined in the JICA and EMPI study as one of the risky neighbourhoods in Istanbul (Ilkisik et al., 2010).

The scope of the Earthquake Master Plan for Istanbul includes work to be done in the following areas: assessment of the current situation; seismic assessment and rehabilitation of existing buildings; aspects of urban planning; legal issues; financial issues; educational issues; social issues; issues of risk management and disasters. The Istanbul Metropolitan Municipality has also set up a strategic plan for Istanbul's disaster mitigation (SPDMI) to reduce seismic risk by focusing on the construction of buildings resistant to disaster (World Bank, 2018).

2.2. Seismic risk management and planning in Ciudad de Mexico city

The city of Mexico is one of the largest urban agglomerations in the world. This city has grown steadily since the 1930s both physically and demographically, reaching the climax in the 1960s, and by the 1990s physical expansion (urban expansion) has formed a continuous urbanized area (World Bank, 2011). Mexico City has the largest metro system in Latin America, over 200 km (Dickson et al., 2012). The city of Mexico extends in all directions, but mainly to the east and north, where there are less restrictive physical barriers. On the one hand, much of the older, but not necessarily poorer, central city is exposed to high earthquake risks, while most peripheral areas are relatively safe in earthquakes (Mitchell, 1999a).

The geophysical characteristics of the city, the size of the population and the presence of the risk of multiple natural hazards underline the city's need to implement urban management programs (World Bank, 2011). The last major earthquake in Mexico was in 1985 and was 8.2M magnitude (Nadelman et al., 2019).

The international community has drawn attention to the disaster risk of Mexico City. The World Bank is involved in disaster risk assessment in Mexico, making recommendations to reduce this risk and support the process. The World Bank recommends Mexico to adopt a three-steps approach: to identify risks, reduce possible damage and transfer risk to insurance companies and capital markets (Kreimer et al., 1999).

The Mexican Government is duly focusing on four key areas: "Strengthening the regulatory and supervisory requirements of the insurance sector, establishing a comprehensive disaster financing structure, promoting public insurance policies related to loss reduction programs in uninsured sectors, and strengthening risk assessment and the implementation of structural measures, such as micro-zoning and building code compliance". (Guerra-Fletes, et al, 2006).

The Urban Risk Assessment Approach (URA) can be initiated as part of the urban planning process so that it can be integrated with existing urban management tools and functions (World Bank, 2011).

The URA methodology has been implemented in four cities (Mexico City, Jakarta, Dar es Salaam and São Paulo) and will be done again with the support and guidance of various international agencies as it is launched globally.

In the two decades since the earthquake, Mexico has taken important steps in addressing the risks of earthquakes and other dangers. These are: technological advances in earthquake monitoring and citizen training programs (evacuation simulations, disaster readiness in hospitals). This includes developing their geographic information systems (GIS) capabilities and modelling for risk assessment and anticipation. The Community was actively involved in the 1985 recovery process, which led to the creation of the Ministry of Social Development in 1987 (Secretaria de Desarrollo Social - SEDESOL) with a role in improving communication and cooperation between the government and civil society (Nadelman et al., 2019).

For monitoring and warning in the event of earthquake, it was implemented in Mexico in 1991 The seismic alert system (SAS) (Cuauhtémoc et al., 2005). The most important of these include: The National Civil Protection System (Sinaproc) set up in 1987 to coordinate disaster readiness and response and the 1988 National Centre for Disaster Prevention (CENAPRED) hosted by the Autonomous National University of Mexico to link the world research and policy (Kreimer et al., 1999).

In 1996, the Mexican government created the Fund for Natural Disasters (Fundo para Desastres Naturales (FONDEN), made up of three separate funds for infrastructure, agriculture and individual assistance (Earthquake Engineering Research Institute (EERI), 2003).

In order to increase FONDEN's ability to fulfil these responsibilities, in 2002 the World Bank provided FONDEN with funds of 404 million USD, allocated for re-capitalisation and disaster management activities (UN/ISDR, 2004,).

Since January 2015, the early warning system of the meteorological phenomenon has been functioning. It was produced by the Mexican Spanish Meteorological Service (SCiESMEX). The aim is to provide a verified warning to the Mexican Centre for Disaster Prevention (CENAPRED) and to the public almost in real time (De la Luz et al., 2017).

2.3. Seismic risk management and planning in Bucharest city

The city of Bucharest covers an urban area of about 285 km^2 and is located in the impact area of the Vrancea earthquakes (Fig. 2). In the case of Bucharest, the geometry of the source of Vrancea earthquakes with intermediate depth remains almost the same throughout the city (Bala et al., 2011). The earthquake that occurred on March 4, 1977, caused the collapse of 32 high-rise buildings in the central area of Bucharest and the deterioration of many buildings (Mândrescu et al., 2007).

Bucharest is a city with over two million inhabitants and rapidly developing. Thus, the civil engineering industry is facing new challenges related to the need to have deeper buildings with deeper underground, a developing network of subway lines and several bridges with foundations made of large diameter stones. All of these new works have an important impact on the stability of the upper soil (Poncos et al., 2013).

Because post-disaster planning is essential for providing emergency services and other civil protection services in affected areas (Merciu et al., 2018) the risk analysis and coverage plan was adopted (PAAR).

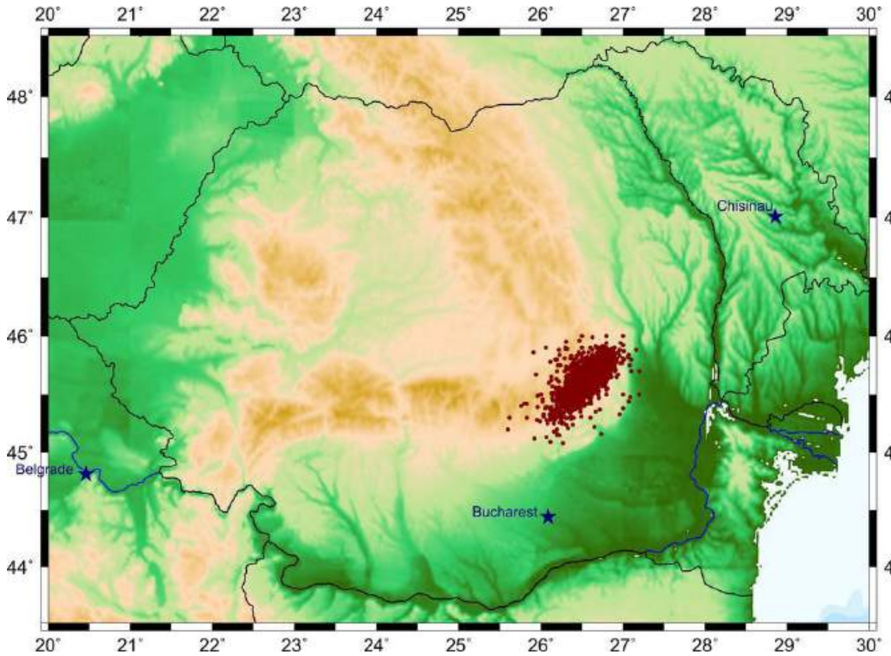

Figure 2. *Subcrustal seismicity of the Vrancean epicenter (depth> 60 km) (ROMPLUS catalogue, Oncescu and colab., 1999)*

PAAR includes: the potential risks identified at the level of the administrative-territorial units, the measures, the actions and the resources necessary for the risk management.

PAAR's objectives are to ensure that all factors involved know the tasks and attributions that occur prior to, during and after the emergence of an emergency situation, to create a united and coherent framework of action for the prevention and management of emergency generating risks and to ensure an optimal response in an emergency, appropriate to each identified risk type.

The design of the capacities and resources necessary for the response, their planning so as to minimize the human and material losses, cannot be achieved without an assessment as close as possible to the reality of the seismic hazard present in the capital. In the case of a high intensity earthquake, it is necessary to analyse the emergency situations that can be generated by the damage of the high and very high buildings in Bucharest and the way of intervention in these buildings. The area with the highest seismic risk at the city level is the historical centre (Gheorghe and Armaş, 2015).

Also in 2016 a rescue command point (fire brigade, doctors, and representatives of public utility companies) was put into use in Bucharest and will bring together the dispatchers of all forces intervening in the event of a major disaster (Ichim, spokesman for Bucharest Town Hall).

3. Comparative analysis

Vulnerability is the potential for loss. The most common change in the components of the hazard is the increase in polarization and spatial segregation of groups with different degrees of vulnerability to disaster. Qualitative contrasts are the clearest in major cities in developing countries (e.g. Mexico City, Lima, Dhaka, Bucharest), "but the sheer volume of recently arrived poor migrants from rural areas tips the quantitative effect heavily towards the poor end of this spectrum" (Mitchell, 1999a).

Recently, several organizations and researchers have focused their interest in developing standardized tools to help governments and stakeholders understand, monitor and establish disaster risk indicators and benchmarks, among which Cardona (2010), Mitchell (2003) and other organizations such as PNUD and the World Bank. The World Disaster Reduction Conference, organized in January 2005 in Kobe, Hyogo-Japan, adopted a "Framework for Action 2005-2015: Strengthening the Resilience of Nations and

Communities in case of Disaster", known as the Hyogo Framework for Action - HFA. This framework includes five thematic areas that set out an initial core of principles and objectives, each of which includes several key components to be analysed (Fernandez et al., 2019): political commitment and institutional development (governance); identifying risks; knowledge management; applications for risk management; preparation and management of emergency situations.

Istanbul is definitely ahead of the overall management plans in the catastrophic risk implementation process. The practice, which reflects the efforts of the city to reduce physical, social and institutional vulnerability, Istanbul City Hall (IMM) has requested at four major technical universities: Bogazici, Istanbul, Middle East and Yildiz, to prepare a Master Plan for Earthquake in Istanbul. For the implementation process, the city decided to focus on urban renewal, refurbishment of selected structures, application of building codes and universal earthquake insurance for general purpose buildings (Fernandez et al., 2019).

In 2015, the PEER report (Evaluation Program for EU cooperation) was presented. This report is an analysis of the situation in Turkey as presented in December 2015. Turkey's risk management system is organized around the risk management cycle and is particularly strong in terms of readiness and response (EERP). The problematic areas in the Turkish legal system that may create obstacles to these strategic plans are: issues related to institutional responsibilities; planning issues; issues related to the embedded environment (Fernandez et al., 2019)

Ciudad de Mexico introduced a system of disaster management indicators. This is a multidisciplinary system that takes into account the expected physical damage, the number and type of economic losses, as well as social, organizational and institutional factors such as social fragility and the lack of resistance of the exposed community. Scenarios of deterioration previously developed for the city are used together with a set of indicators to develop this urban management program. Thus, an earthquake (7.6 on the Richter scale) in the South-western state of Colima on January 21, 2003 tested the measures implemented by Mexico to improve disaster availability. A reconnaissance team at the Earthquake Engineering Research Institute (EERI) visited the municipalities of Colima, Manzanillo, Tecomán, Comala, Coquimatlán, Villa de Álvarez, Ixtlahuacan and Armería the day after the earthquake, investigating the effects of the earthquake as well as the government's response. The team described the response as "fast and well managed" (Reporting of damaged structures was mostly by public teams doing rapid visual assessments, Earthquake Engineering Research Institute, 2003),

The disaster risk in the city of Bucharest is treated in a reactive manner and limited preventive measures have been implemented. In addition, there is an obvious need to improve the exchange of information between relevant government agencies. However, implementation of the early warning Rapid Earthquake Warning System (REWS) is operational from 2013 (Ionescu et al., 2016).

Table 1. Comparative analysis of risk management and planning in Istanbul, Mexico City and Bucharest

Thematic areas/ Components	**Istanbul**	**Mexico City**	**Bucharest**
Politics and planning	EMPI	CENAPRED	PAAR
Legislation	Disaster Law Civil Defence Law Development Law Law of Municipality	General Civil Protection Law (LGPC) General Climate Change Law (LGCC)	Regulation on defence against the effects of disasters caused by earthquakes and / or landslides; Regulation on Prevention and

Thematic areas/ Components	Istanbul	Mexico City	Bucharest
	(1958) Building supervision Law	International Development Cooperation Law (LCID) Organic Law of the Army and Air Force	Management of Emergency Situations specific to earthquake risk and / or landslide;
Resources	National Allocation Fund Insurance for protection against earthquakes, for risk transfer adopted at the level of nations	FONDEN	Civil compulsory insurance in case of earthquake Building consolidation program of Class I buildings of seismic risk and posing public danger
Organizational Structures	Council of Disaster Management Centre (AYM) Disaster Coordination Centre (AKOM)	SEDESOL	Emergency Situation Committee of Bucharest Municipality, Operational Centre with Permanent Activity - ISUBIF Local Committees for Emergency Situations of Districts 1-6, Operational Centre for Temporary Activity
Risk Assessment	- Maps of seismic activity -Scenarios of damages in case of earthquakes	GIS maps for modelling, assessing and anticipating risk	- Maps of seismic activity -Earthquake damage scenarios -Death toll and fire damage estimates available.
Early Warning	- Early warning system that also aims at preventing secondary effects such as fire, gas and electricity cuts.	Seismic alert system (SAS)	Rapid Earthquake Early Warning (REWS)
Education and Training	General aspects related to Earthquake risks is offered in primary and high schools	Evacuation simulations, disaster readiness in hospitals	-Little training or formal education in primary and high schools
Research	Major focus has been the physical vulnerability of buildings	Technical studies related to risk monitoring	-Mainly technical research addressed to construction, hazards monitoring,

4. Conclusions

For risk management to be effective, it can no longer be a separate aspect of urban management; it must become a component of integrated programs that are designed to respond to the wider objectives of urban sustainability. Consequently, the purpose of risk management projects is to bring together and activate in every sector of risk, the related components of public administration, business and industry, NGOs and representatives of local communities in the long-term management of urban risks, to conclude mutual understanding of conduct and control (Nilay et al., 2019).

This study evaluated the suggestions for risk management projects in Bucharest, Ciudad de Mexico and Istanbul. Following the analysis of these projects, we can say that the most complete risk management project is in Istanbul. Project, which can be taken as example to improve the risk management situation for Bucharest.

Risk analysis and assessment, especially earthquake risk, does not seem to be a problem in the studied cities. All these cities have a good understanding of the dangers they face and major social and structural vulnerabilities have been identified; Consequently, the associated risks are fairly well known and accurately mapped. However, serious limitations on governance and knowledge management have occurred in most cities.

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Gravelometric image analysis of sediments (Prahova River, Romania)

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Abstract. The paper presents a method of sediment gradation using the Basegrain software to analyse pictures taken from the bed surface in 20 locations along the upper course of Prahova River, Romania. Sediment grading curves and median diameter, median diameter (d50) values for each sample, obtained by the virtual sieving method were compared with the ones obtained through the Wolman - pebble-count method along a shorter reach. Results show a good match between the two methods.

Keywords: *image analysis, Wolman method, sediment grading curves, mean diameter, virtual sieving*

1. INTRODUCTION

It is well-known that field surveys for volumetric sampling and subsequent laboratory sieving of grain sediments from riverbed channel are very time and resource consuming, requiring equipment, staff and facilities for sampling, transporting, drying, weighting and processing. Moreover, the measurements can mostly be performed during summer, thus imposing a time constraint on researchers (Stähly et al., 2017).

During the last years many researchers have developed a series of image-processing techniques for analysis and classification of riverbed surface and armor layer sediments of mountain rivers (Buscombe, 2010; Graham, 2005; Weichert, 2004; Hate and Shelke, 2016; Rüther et al., 2013; Groom et al., 2018). They compared these virtual sieving results with the ones from classical methods such as sieving and weighting, individual pebble measurement with gravelometers or calipers, which are more consuming in terms of time and effort. (Rüther et al., 2013; Stähly et al., 2017)

A major advantage of the optical-processing techniques is they require limited resources, only for taking pictures with a camera and a computer. Furthermore, a large number of digital samples can be acquired during the warm season, thus eliminating the need of transport and storage. The pictures can be processed during the cold season.

Therefore, object-detection software for quantitative analysis of images were developed similar to the ones used for biology microscopic applications (such as pattern/colour recognition, cell counting, classification, clustering, sizing and/or morphological analysis). Platforms like Matlab, Image J (Java based) are the most used for image analysis (Rishi, 2015). In the present paper the freeware Basegrain software is used, which is based on computer algorithms under Matlab (Hate and Shelke, 2016; Deter and Weitbrecht, 2012).

Since the riverbed surface material of upper Prahova River is coarse enough to allow identification and delimitation of each particle in a picture, such an image-processing method was used to obtain the sediment grading curves in multiple locations along this study reach.

The objective of the paper is to assess the usefulness of the imagistic method for determining the sediment gradation curves and median diameter of multiple samples taken from the surface layer of the exposed sediment side bars along the upper course of Prahova River. A comparison with results obtained through the Wolman (pebble count) method is made to verify its accuracy (Bunte et al., 2009).

2. STUDY AREA

The 56 km course of Prahova River stretches from its source (at Predeal locality) to the downstream junction with Doftana tributary, near Campina locality. At the exit of the Carpathian reach the river passes through a narrow gorge, the Sinaia-Posada defile (Fig. 1).

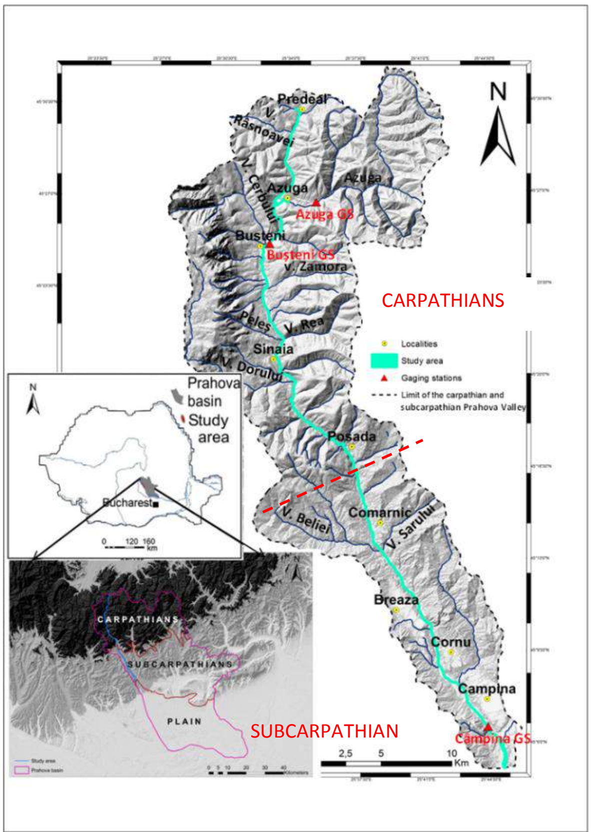


Figure 1 Upper course of Prahova River, with main tributaries; Carpathian and Subcarpathian reaches

Along the Carpathian river reach the morphological pattern of the Prahova River is mainly sinuous, with longitudinal side bars (Leopold and Wolman, 1957). Mean thalweg slope is about 1.25%, sinuosity index is 1.14 and average main channel bankfull width is about 17 m (Brașovanu et. al, 2018; Armas et al., 2012). Along the Subcarpathian river reach the thalweg slope is about 1.17% and the morphological pattern has changed due to heavy anthropogenic pressures within the last century, from braided to a mixture of braided and single-thread (mean sinuosity index 1.06) with deep incisions up to 3-5 m in the thalweg (Armaş, 2012; Brașovanu, 2018; Ioana-Toroimac et al., 2015; Ioana-Toroimac 2014). However, there are areas where multiple lateral channels still exist, particularly towards the downstream junction with Doftana River. Main braiding index along the downstream reach is 1.75-2.72, whereas average main channel bankfull width increases to 28 m. The sediment from the bed is a mixture of sand, gravel and boulders.

3. METHOD

To investigate the grain size variation in the surface layer, we performed two field surveys along the study reach of the Prahova River. First one was undertaken 2012 to apply the Wolman method for the Subcarpathian Comarnic-Câmpina reach and the second one in 2017 to apply the image-processing method for the entire upper course of the Prahova River.

The **Wolman's – Pebble Count method** was used to perform the granulometric analysis of the Prahova bed surface deposits from side bars, (Wolman, 1954ş Leopold et. al., 1964; Kondolf, 1992, 1997). The technique consists in the random selection and measurement of sediment particles removed from the riverbed surface by an observer, who walks across the streambed and samples at each three steps, without looking, the first particle encountered at his/her toe (Bunte and Steven, 2001). The method was applied using zig-zag paths to allow sampling particles from riffles, pools and meander bars (Olsen et. al., 2005; Bunte et al., 2009). The entire 18 km reach was divided into six sampling sub-reaches chosen after thorough in-situ visual inspection in accordance with their either erosion or deposition character (Fig. 2).

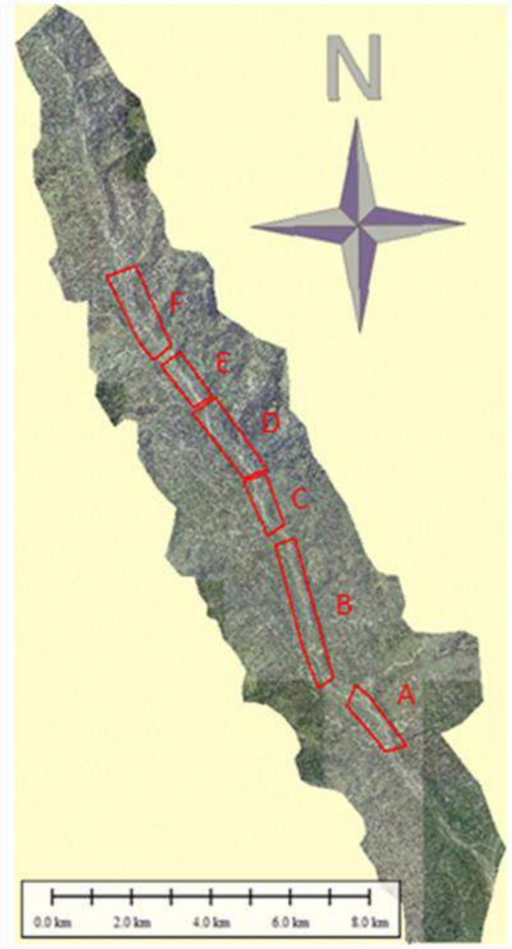


Figure 2 *Pebble count method sampling subreaches*

870 sediment particles were sampled along these sub-reaches as shown in Table 1, for which the intermediate diameter was measured with a calliper and recorded.

Table 1 No. of samples within each sub-reach

Subreaches	Number of samples
A. Campina – L. Cornului	121
B. L. Cornului – Cornu	145
C. Cornu-Breaza	154
D. Frasinet-Nistorești	158
E. Pl. Cornului – G. Beliei	171
F. Podul Corbului – Comarnic	121
total	870

For the **image-processing method** 20 equally-spaced sampling locations were selected, at a relative mean distance of 3 km (Fig. 3). These were placed on exposed natural and accessible areas (during the low flow periods) of approximately 1 m^2, situated on side bars or mid-channel bars, close to the water limit (Radoane et al., 2008). In all the sampling locations a coarse surface sediment layer (with coarse gravel and cobbles) was identified, beneath which a finer sediment layer (of finer gravel and sand) was found.

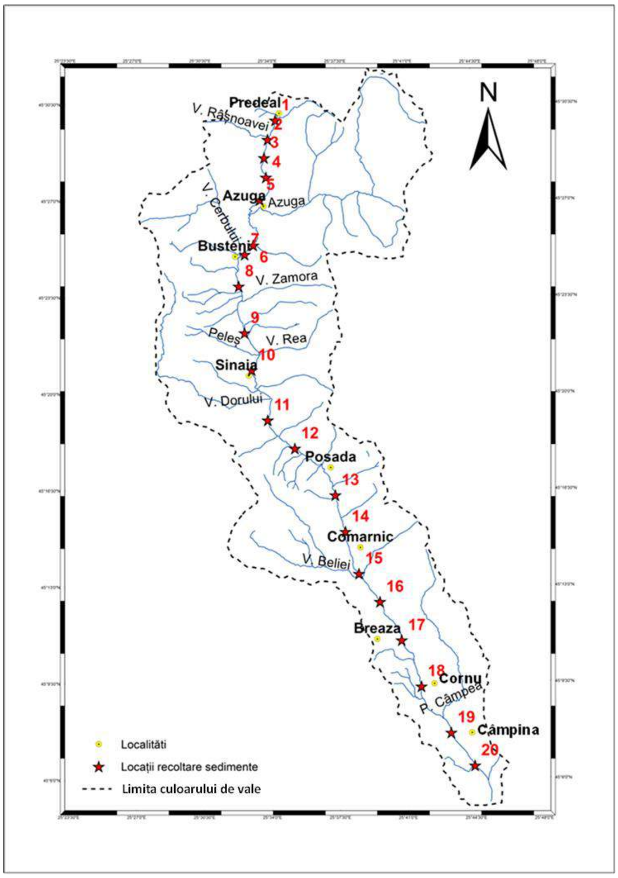


Figure 3 *Sediment pictures sampling locations along Prahova River reach*

The sampling method consisted in taking pictures of the riverbed surface as vertical as possible in order to minimize the angular distortions. Pictures were taken inside of two aluminium 50 cm x 50 cm frames, one of them provided with a 5 x 5 cm wiring mesh / network for quick visual inspection.

For the image analysis the Basegrain software version 2.2.04, written in Matlab (Detert and Weitbrecht, 2013) was used. For each location the most representative picture was processed.

After the calibration of dimensions along two rectangular axes, the image processing algorithms implemented into the software allowed the identification of interstices and particle edges (Detert and Weitbrecht, 2012). Within the picture taken through the frame without mesh, a smaller rectangular area was selected to calibrate the image identification parameters. Filtering thresholds were progressively adjusted for an optimal identification of particle edges and surfaces as well as the gaps between them.

When the grains cannot be correctly identified by the Basegrain software because of their nonuniform colours (stripes, spots etc.) each particle can be re-coloured by using a usual picture processing software. Also, in case of incorrect identification of particles, the software allows merging or splitting the processed areas by their actual edges.

The morphometric characteristics of each particles can be identified, such as: maximum and minimum diameter (*a* and *b*), their aspect ratio (*a*/*b*), inclination angle of the axis along the maximum length with the horizontal direction, area, perimeter and mass center coordinates, and the sediment grading curve with main characteristic diameters: d_{30}, d_{90} and mean diameter, d_{50}, (Fig. 4).

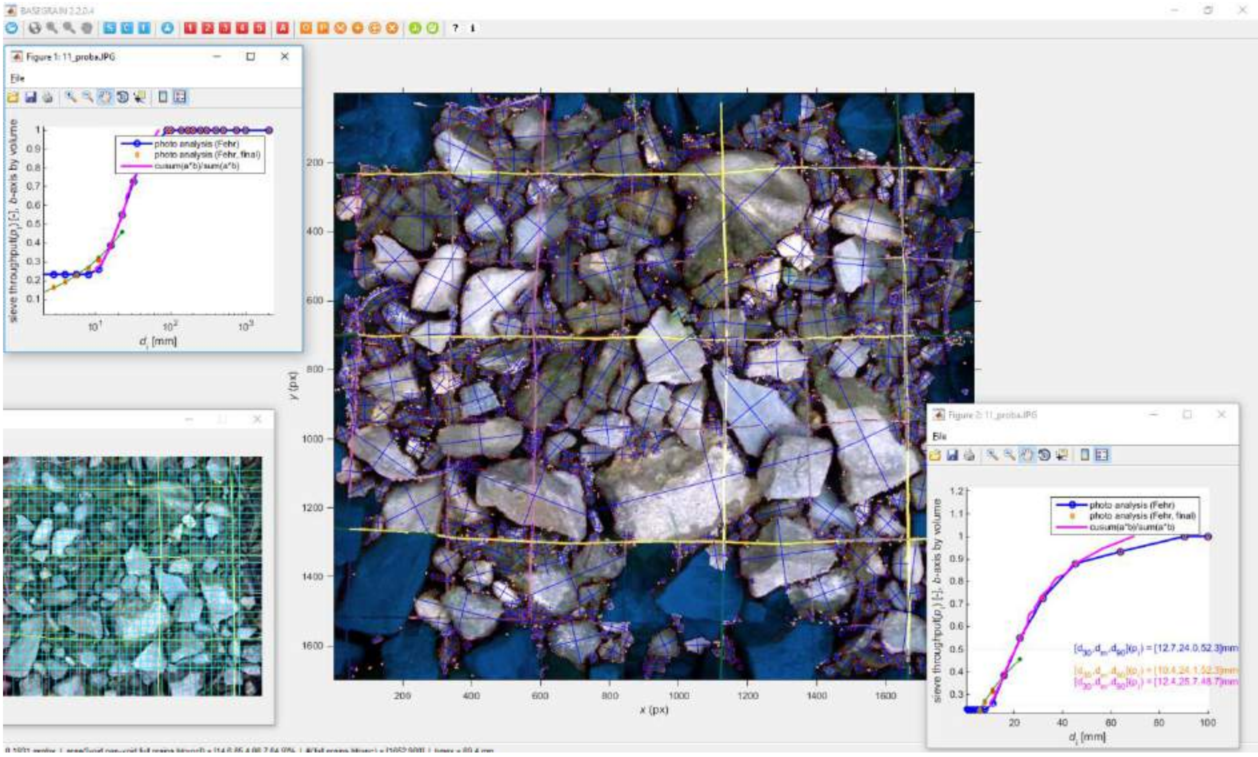


Figure 4 *Example of virtual sieving through image processing technique with Basegrain software (Prahova River bed sample)*

4. RESULTS

For each sub-reach along the Subcarpathian Prahova River where the Wolman method was applied, a cumulative size distribution curve of the particle diameters was determined according to the Wentworth grain size scale and represented in a plot in Figure 5. The results show that Prahova River has within its Subcarpathian reach a gravel bed surface with a sedimentary mixture of sand, boulders and mainly pebbles with a d_{50} between 22 and 33 mm. From these curves the mean diameter of the samples can be directly determined along each surveyed sub-reach.

Results obtained from the Basegrain image analysis software were saved in an Excel file as a table containing for each sediment particle its number and all the aforementioned morphological parameters.

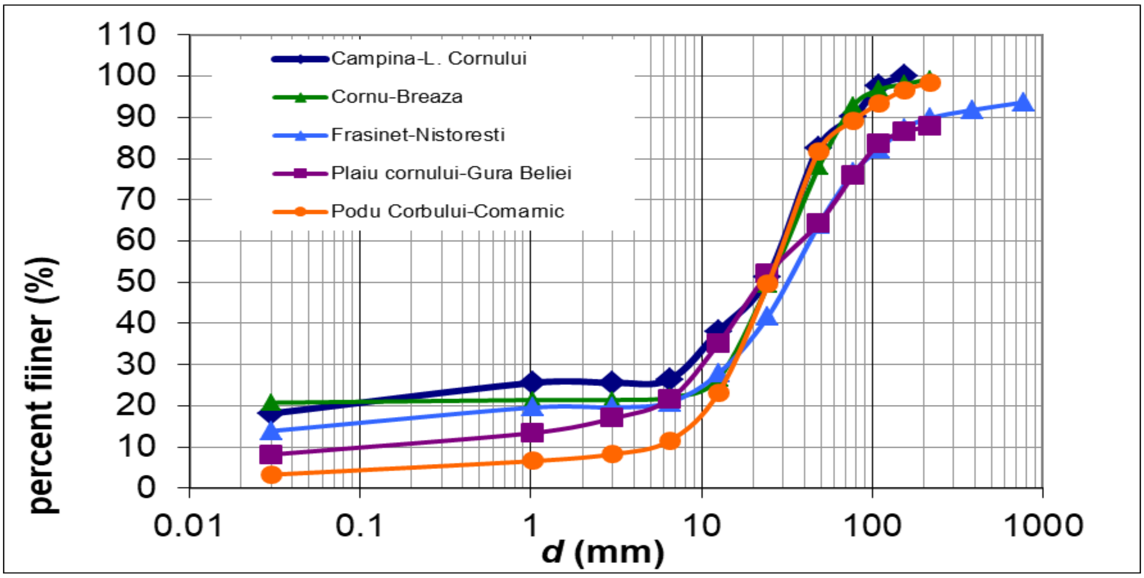


Figure 5 *Pebble count method sampling sub-reaches*

All these data were further on classified into grain size ranges through virtual sieving from which a granulometric curve is obtained. The diameter axis of the curve can be displayed using linear or base-10 log scale (Fig. 6). The Basegrain software computes the diameters of granulometric fractions by using 6 formulas. In this paper, an average of these values was used to represent the granulometric curves for all sampling sites (Fig. 6).

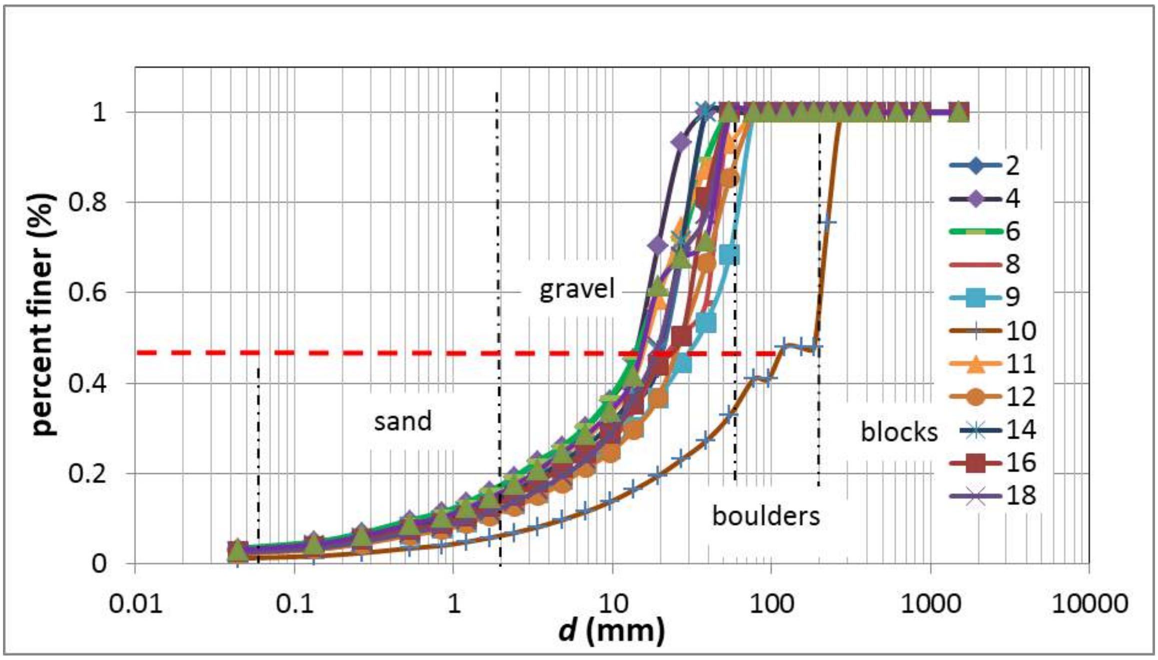
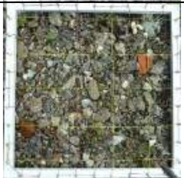


Figure 6 *Granulometric curves through "virtual sieving"*

The mean diameter, d_{50}, for the samples falls within the range 15-32 mm (specific to gravels), with one exception in location 10, where a much larger value of 155 mm was obtained (Table 2).

It should be emphasized that this maximum value of the mean diameter was registered downstream the Sinaia 0 dam (at the bridge, downstream the broad-crested spillway), thus proving the importance of anthropogenic impact on the solid transport of river. Therefore, this value, attributed to the human impact, was removed.

Table 2 Selected locations and pictures taken through the mesh 50x50 cm frame with mesh

Sample no.	DS distance	Cross-section photo	Sediment bar surface photo
2	55.4		
4	52.4		
6	46		
8	39.4		
10	35.9		
12	28.6		
14	21		
16	15.4		
18	7		
20	1.7		

The d_{50} values resulted from the image processing method were compared with the same values obtained from Wolman method along the downstream Câmpina-Comarnic river reach. A good match between the results of the two methods may be seen in Figure 7. In both Table 2 and Figure 7 the downstream (DS) distance is used, with respect to the confluence of Prahova River with its Doftana tributary.

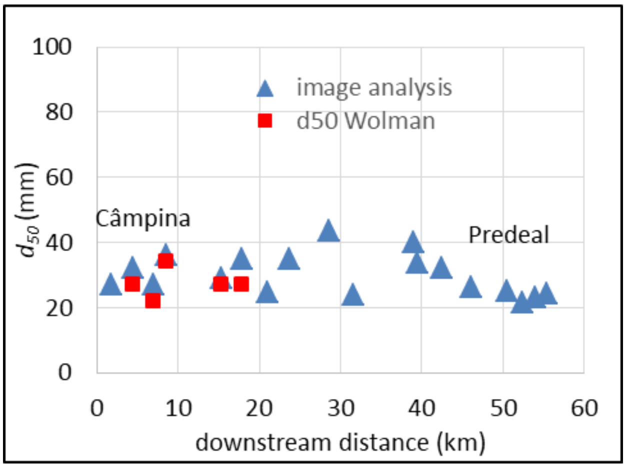


Figure 7 *Mean diameter along Prahova River reach through image-processing and Wolman methods*

5. CONCLUSIONS

One can see from Figure 7 that the mean diameter of the riverbed surface, resulted through the image processing method is only slightly smaller than the one obtained through the Wolman pebble count method. Stähly et al. (2017) provided a 0.83-0.86 ratio between the diameters obtained through the virtual siving and classical sieving methods. Bunte and Abt (2001) state that using the Wolman technique, particles finer than 4 mm are lost. These conclusions are in accordance with our results. Even though Graham et al. (2010) and Strom et al. (2010) showed the image processing method provides an accuracy similar to classical methods for seven distinct rivers, having different lithological and granulometric riverbed material, they suggested to process multiple pictures from the same location. This is recommended particularly because the sedimentation pattern at the upstream or downstream ends of the sediment bars can be different.

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Downstream coarsening of subsurface sediment grain size along upper Prahova River (Romania)

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Abstract. The paper presents the results obtained from a subsurface sediment grain size analysis along the upper, gravel-bed, Prahova River, Romania. Samples were taken from 20 locations over a 56 km study reach and were subsequently sieved and weighted in the laboratory. Both d_{50} and d_{84} characteristic diameters were plotted against distance and an overall downstream coarsening was identified. Considering the natural and anthropic context of the studied reach, hypotheses to explain this trend were launched.

Keywords: *sediment grading curve, mean diameter, sieve analysis, volumetric analysis, gravel-bed river, d_{50}, d_{84}, downstream coarsening, downstream fining*

1. INTRODUCTION

The analysis of river sediment patterns provides valuable information about the interrelationships between the control and response variables that influence river channel changes (Armas et al., 2012; Rădoane et al., 2008, Dumitriu et al., 2011; Rădoane et al., 2002).

On the one hand, natural control variables (such as: climate, geology, lithology, topography, soil cover, slope processes, land use, tributaries) act at the macroscale catchment context and determine long-term liquid and solid fluxes into the river channel.

On the other hand, anthropic control variables (such as: channel works, river regulation, road/railway construction, land use, deforestation / afforestation, channel gravel mining, small-hydropower plants) induce a shorter-term geomorphic adjustment of river morphodynamics.

Response variables that characterise channel morphology include: channel planform, bed slope, bankfull width and depth, meandering and braiding indexes, and sediment size distribution and sorting.

In this context, knowledge on particle-size variation along a riverbed is necessary in order to understand the complexity of the interrelated physical stream processes such as hydrodynamics and sediment transport against the background of human impact.

In gravel-bed river reaches with fine sediment supply from upstream and/or tributaries, a downstream fining of sediment bed material is a common phenomenon. This is mainly due to slope reduction in the flow direction, which decreases bed-load sediment transport rates and leads to a combination of particle abrasion, wear and selective transport (Shumm et al., 1973; Fergusson et al., 1996).

Several researchers (Surian, 2002; Brummer et al., 2003; Sear, 1992; Gibson, 2016; Dumitriu et al., 2011) stated that a reverse tendency of downstream coarsening of bed material may appear due to major tributary coarse sediment input, downstream dams (Veicat, 2006) and where the flows are substantially regulated.

The upper section of Prahova River passes through an area that has the highest population density in the Subcarpathians. Consequently, the anthropogenic impact upon the river has been extremely intense, especially over the past 200 years (Ioana-Toroimac, 2015; Armaș, 2012; Brașovanu, 2017).

The purpose of this study is to analyse the variability of sediment particle size from the subsurface layer along a 56 km reach of the upper Prahova River, through sieve analysis. Correlations between the natural and man-made impacts and particle size variability are analysed and explanatory hypotheses are then proposed.

2. STUDY AREA

Prahova River is a second order tributary of the Danube River, located in the central-southern part of Romania. Its source is situated in local administrative unit Predeal, in the Carpathian Mountains, (1037 m above sea level), and its mouth is at Patru Frați (63 m a.s.l.), where it joins Ialomița River. Its total length and watershed area are 190 km and 3750 km^2, respectively (Fig. 1). The mean annual flow rate at its mouth is 27 m^3/s (Brașovanu, 2018).

The upper Prahova River, considered from the source to the confluence with its tributary Doftana, passes through the Carpathian and Subcarpathian reaches (Fig. 1). It has a length of about 56 km and a difference in altitude of 2140 m. The corresponding channel slopes over these reaches are 12.5 and 11.7 m/km, respectively. The narrow watershed has a non-symmetrical shape and the two reaches are linked by the Posada Defile (Fig. 1).

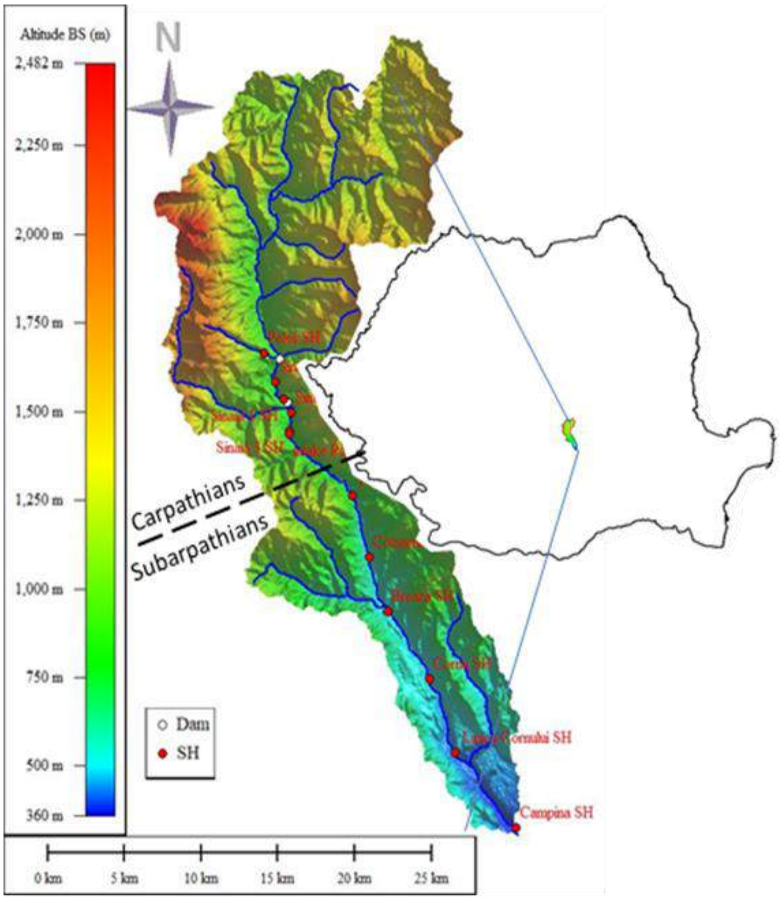


Figure 1 *The study reach of upper Prahova River (SH – Small Hydropower plant)*

Over the last 200 years, the area has been greatly impacted by anthropic activities such as: construction of railway, roads and bridges, channel regulation and bank protection works, gravel mining, building of two small dams and 10 run-of-river hydropower plants, afforestation/deforestation, oil exploitation, population growth and tourism (Brașovanu, 2017; Armaș et al., 2012; Dobre, 2009).

All the aforementioned factors induced important modifications in the morphology of the river channel, affecting both the longitudinal profile and planform. These alterations consisted of pronounced bed incision (up to 3-4 m in some locations), channel narrowing and a transition from braiding to a mixture of braiding and sinuous, single-thread planform patterns (Armaș, 2012; Ioana-Toroimac, 2014; Leopold et al., 1964).

Mean annual flows at Bușteni and Câmpina gauging stations are 4.9 and 8.15 m^3/s. Over the past decades, an increasing number of high intensity flood events were recorded in the study reach.

The mean annual suspended sediment flow, at Câmpina Gauging Station (at the downstream end of the study reach), shows a decreasing trend over the past 50 years, from 15 to 9 kg/s (Brașovanu, 2017). A similar trend was documented for minimum and maximum annual sediment flows (Brașovanu, 2017).

3. METHOD

Field surveys were conducted during the autumn of 2017 to gather sediment samples in 20 locations along the upper reach of Prahova River. The locations were selected in the proximity of the water, on the exposed side or mid-channel bars (Bunte, 2001; Radoane et al., 2006, Hedrick et al., 2013), which were placed at a mean relative distance of about 3 km (Fig. 2). From the sampling area of approximately 1 m^2, the surface layer was removed at a depth equal to the largest particle diameter. Samples from the surface layer are analysed in another paper (Gogoașe Nistoran et al., 2019).

For each location, finer particles from the subsurface layer were collected into a large bucket and mixed thoroughly. A representative smaller sample was then extracted into a box, which was subsequently oven-dried and then sieved and weighted.

Nine standard sieves (according to ISO 3310-1/2016 standard) were used to perform the standard grain size analysis of the samples in the laboratory.

4. RESULTS AND DISCUSSIONS

Particle size distribution curves were derived for all sampling locations (Fig. 3 a to d). Characteristic diameters d_{50} and d_{84} were identified using the calculator provided by Gary Parker (2004). One can see the mean diameters, d_{50}, fall within the range 2-8 mm (with an average value of 5 mm, specific to fine gravels), whereas d_{84} fall within the range 4-13 mm (with an average value of 11 mm, specific to medium gravels).

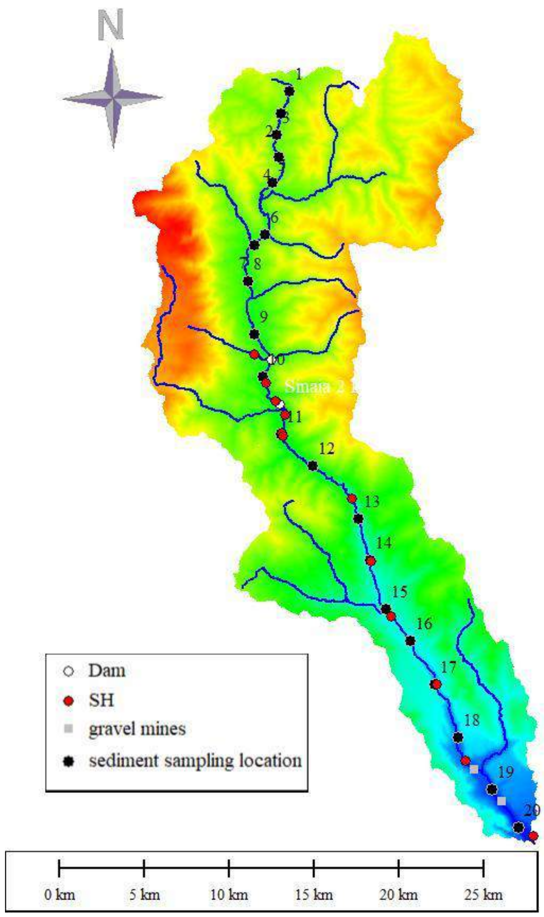


Figure 2 *Sediment sampling locations along upper Prahova River reach*

The resulting diameters were plotted against distance from river source in Fig. 4 and Fig. 5. Sample no. 1 was removed from the plots since it was the only one taken from the riverbed, below the water surface, consisting of a mixture of particles from both surface and subsurface layers.

Diameters show an overall increasing trend with distance, which is consistent with the downstream coarsening phenomenon documented by other authors for gravel-bed rivers (Brummer and Montgomery, 2003; Gibson et al., 2016; Dumitriu, 2011).

According to various authors, downstream coarsening is usually localized, due to coarse material supplied by tributaries, debris flows

(Brummer and Montgomery, 2003) or high energy currents (Solari and Parker, 2000).

This specific feature identified along the upper Prahova River could be explained by the following natural factors: morphometric characteristics of this sediment production zone (steep hillslopes, narrow-elongated watershed) coupled with destructive flash floods produced by high intensity rainfall events and scarce vegetation on high altitude areas.

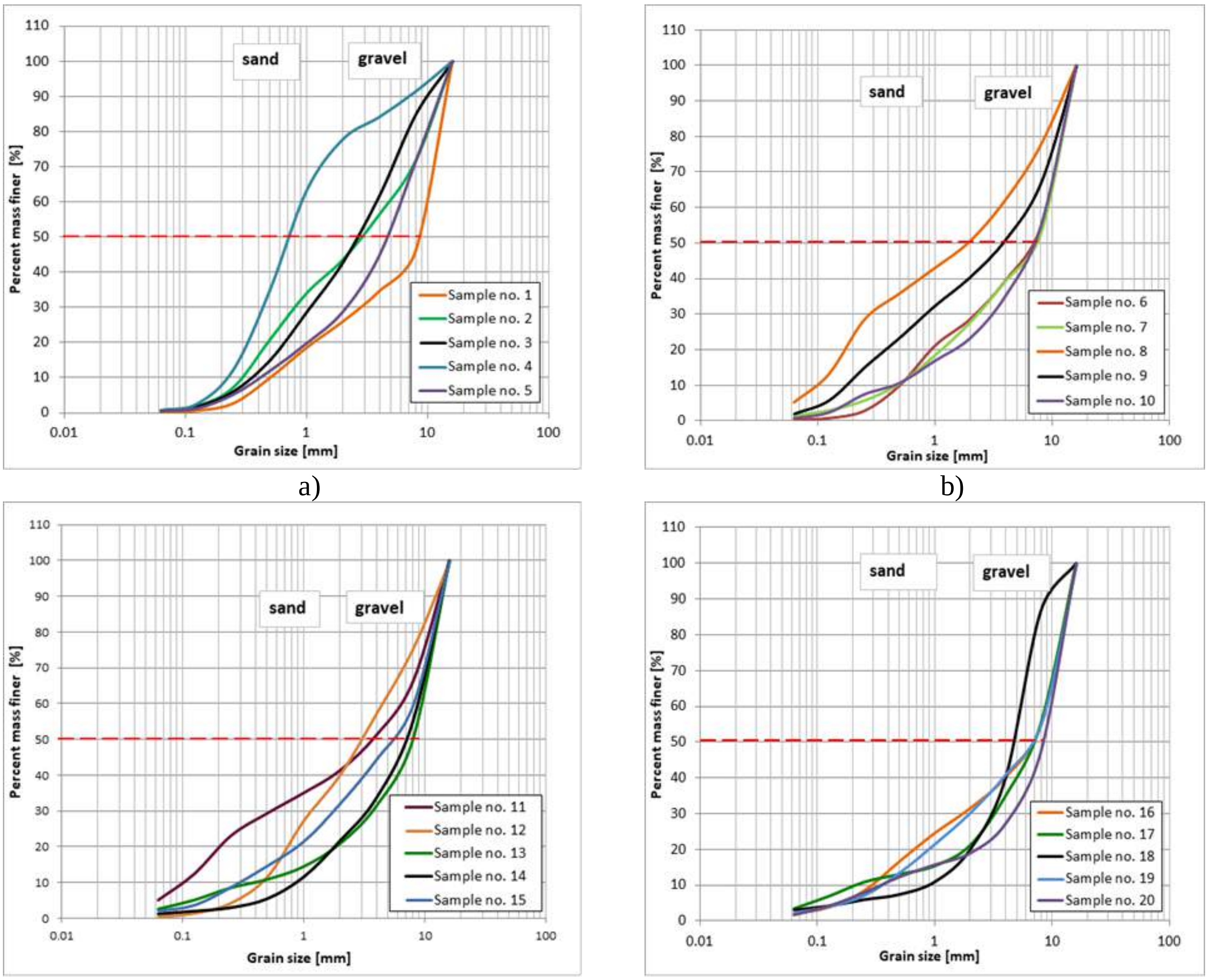


Figure 3 *Cumultative grain size distributions obtained by sieving from the 20 locations along upper Prahova River*

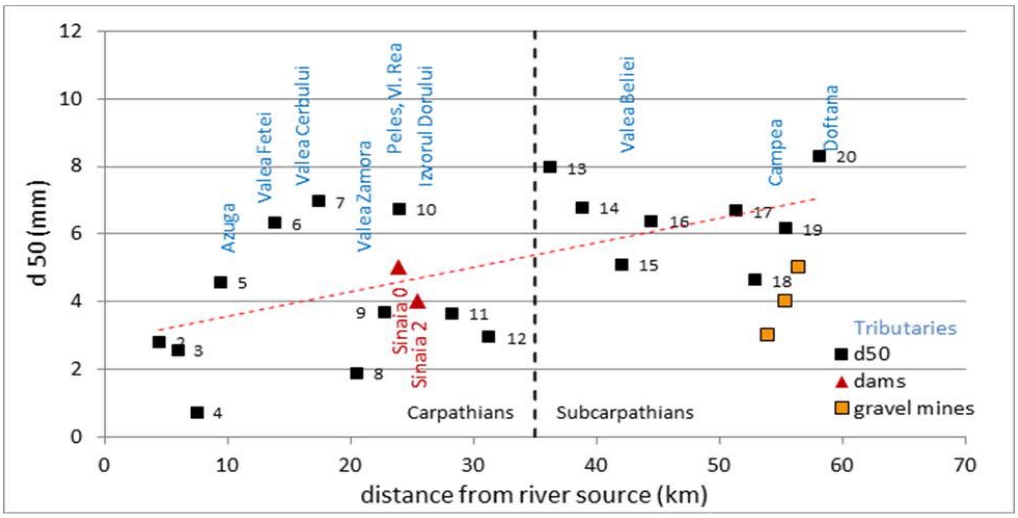


Figure 4 *Longitudinal variation of d_{50} from the subsurface sediment samples (upper Prahova River)*

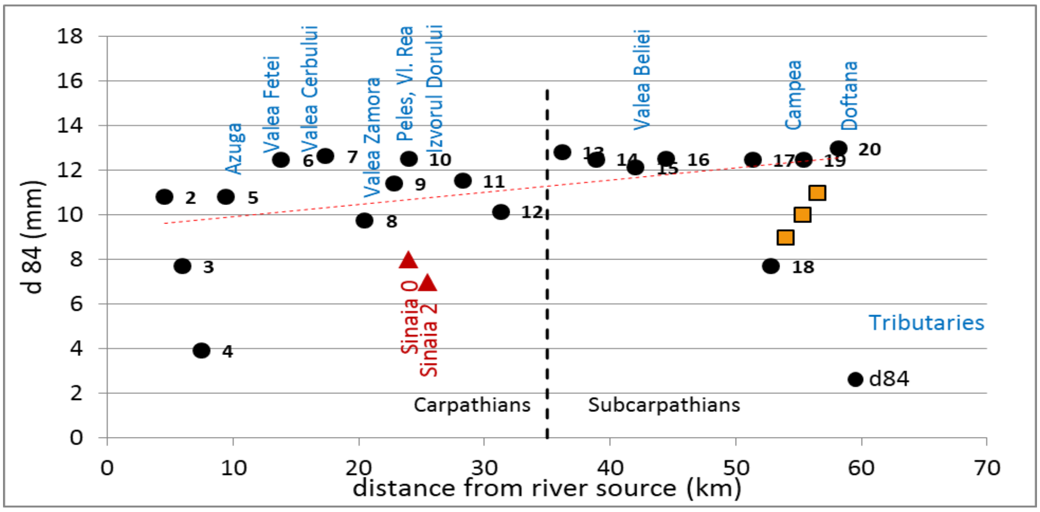


Figure 5 *Longitudinal variation in size of d_{84} from the subsurface sediment samples (upper Prahova River)*

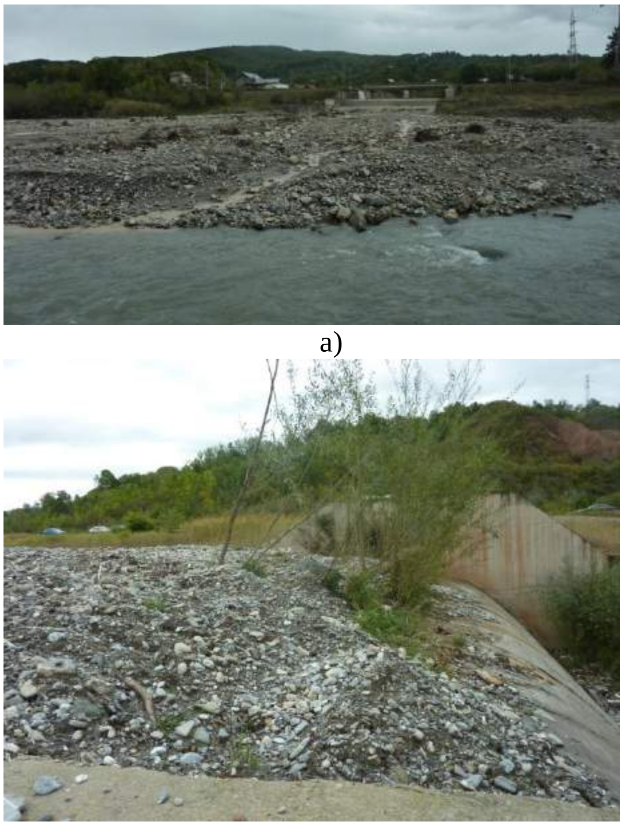
An example of lateral coarse sediment material inflow is the catastrophic flooding and debris flow event that occurred on 13.08.1999 (Sălăjan, 2017) in Bușteni-Poiana Țapului on Valea Cerbului River and on the smaller streams Valea Babei and Urlătoarea (all tributaries of Prahova River).

Another example of important coarse sediment supplied by the Valea Beliei tributary is the alluvial fan formed at the confluence with Prahova River due to frequent upstream slope sliding processes. Figures 6 a) and b) show the Valea Beliei confluence and the spillway filled up with sediments at the intake of the Lunca Cornului small hydropower plant, placed immediately downstream.

On the one hand, from Figure 4 and Figure 5, the local drop in diameters from sampling points 2 to 3 and 4 could be attributed to the small difference in altitude of the watershed and the lack of important tributaries down to the confluence with Azuga River. From location 5 to 6, Prahova River passes through the Genune narrow pass between the confluence with Azuga and Valea Fetei rivers, where the floodplain width narrows from 250 m to 70 m (Brașovanu, 2017), and therefore the channel velocity and sediment transport capacity increase.

The decrease in particle size from sampling point 11 with respect to 10 could be explained by their location downstream of the two dams Sinaia 0 and Sinaia 2 and by the absence of important tributaries.

On the other hand, the increase in grain size from location 13, situated at the exit of Posada Defile, may be caused by large velocities, shear stresses and therefore sediment transport capacity along this narrow stretch.



a)

b)

Figure 6. *a) Alluvial fan at the confluence with Valea. Beliei tributary; b) Sediments deposited up to the spillway crest of Lunca Cornului intake dam, downstream this confluence*

The activity of the gravel mines situated at the downstream end of the study reach could also explain the important drop in grain size from locations 18 and selectively from 19.

Since significant incision was documented by Armaş (2012) and Brașovanu (2017), especially along the Subcarpathian reach of the Prahova River (where the river channel underwent major channel works), it is noteworthy to mention that several other researchers (Kondolf, 1997; Wyżga, 1993; Galia, 2013) argue about the existence of a possible connection between channel incision as a consequence of human impact and the coarsening of bed sediments in gravel-bed rivers.

5. CONCLUSIONS

The results of the grain size distribution analysis performed on samples taken from the subsurface layer of the exposed side or mid-channel bars from 20 locations along the upper Prahova River show a general downstream coarsening trend for both d_{50} and d_{84},which could have impact on stream biota.

In accordance with the explanations advanced by other authors for this unusual trend of gravel-bed rivers, the present paper proposes some hypotheses that match the conditions for the studied case.

From these, we mention: the high difference in altitude of the watershed, deforestation, coarse sediment input delivered by tributaries as a consequence of hillslope processes, incision caused by channel regulation and bank protection works, gravel mining, and presence of two dams.

Whereas hydrodynamic models may highlight the decrease of the onset of sediment transport and a selective transport of finer material along the potentially flow-depleted reaches when operating small run-of-river hydropower plants during low flow periods (Gogoașe Nistoran et al., 2018), a direct effect upon grain size variation in the subsurface, including high flow periods, still needs to be further investigated.

Further links with the variation of grain size from the surface layer, particle size frequency and percentage frequency distribution should be made. Also, given the complex influence of the interrelated control variables, additional systematic sampling is needed to better understand and explain the variation in time and space of the sediment grain size along the investigated reach.

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Multi-criteria analysis for major road infrastructure projects. Case study: Brașov – Bacău Highway

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Abstract. Road infrastructure projects have proven to be a challenging task, particularly in a dynamic setting, such as mountains and hillsides. Such an endeavour entails the integration and processing of cross-disciplinary research, particularly engineering and geosciences. Our study is oriented towards the geographic aspects, specifically the ones involving applied geomorphology. We aim to provide a cartographic solution that reveals the areas suitable for developing a road network, based on a geomorphologic and environmental approach. This is achieved through a GIS-based multi-criteria analysis involving raster data sets of different geodynamic factors, such as geology, pedology, gravitational processes, land use and other environmental components.

Keywords: *GIS, Road Infrastructure, Highway, Multi-criteria Analysis*

1. INTRODUCTION

Transport infrastructure is one of the basic factors of development models of any geographical region. In the current global economic context, competitivity can be sustained through direct investments in this domain, which makes a geographical approach essential in this analytical process.

A development model requires a geomorphological survey, as it has the capacity to identify solutions with the purpose of maintaining a balance between natural and man-made environments (Dobre 2016).

The evaluation of environmental components represents the basis of such an analysis, designed to prevent the problems that may arise in the design, construction and usage of the transport infrastructure.

The area chosen for identifying the optimal route for the Brașov-Bacău highway is the one between the municipalities of Târgu Secuiesc and Onești, namely between Râul Negru and the Tazlău-Cașin depressions. These areas are bordered by a mountainous range, Nemira Hill and Măgura Cașinului, which are part of the Eastern Carpathians. The maximum altitude in the study area is Nemira Hill, with 1642 m a.s.l. (above sea level). Geologically, it mainly consists of flysch sandstone facies (Tarcău and intermediary facies) and flysch limestones. The minimum altitude lies at the bottom of the Tazlău-Cașin depression (Onești municipality) with 167 m a.s.l., an area consisting mainly of sedimentary rocks.

Because a geographical analysis of such a large area requires an abundance of spatial data, in the first stage we chose to focus on a sample area: the contact between the mountain range and the depression area of Oituz River. The aim is to test landscape suitability for a high-speed road in the Oituz Commune.

2. METHODOLOGY

The entire study is patterned on a multi-criteria analysis in which several geographical elements were introduced, like a digital elevation model – DEM (based on contour lines digitized on the 1:25.000 topographical map), slope data, geological data (source I.G.R.) and land use data (Corine Land Cover 2012), see table 1.

The GIS software of choice were Ilwis 3.4 Open and ArcGIS 10.3 suite. Microsoft Office Excel 2013 was used as a .dbf file tabbed data processing software.

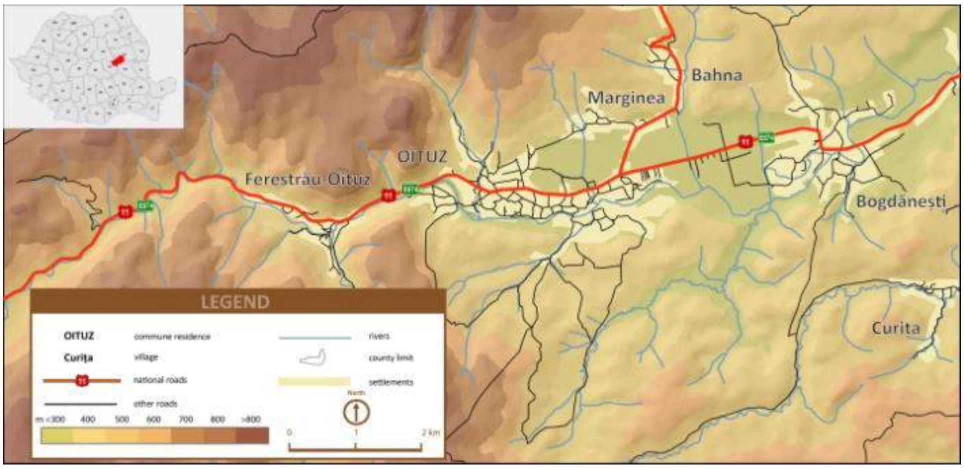

Figure 1. *Study area*

Table 1. Vector data used

Primary data	Source	Type	Usage
Contours	Topographic Map of Romania, scale 1:25.000	Line vector	DEM, slope, multi-criteria analysis
Rivers	Open Street Map	Line vector	Maps, analyses
Settlements	Open Street Map	Polygon vector	Maps, analyses
Geology	Geological Map of Romania, 1:200.000	Polygon vector	Multi-criteria analysis
Land use	Corine Land Cover 2012	Polygon vector	Multi-criteria analysis

In order to create the map of relief suitability for transport infrastructure, we used a multi-criteria analysis in which a range of terrain configuration data (slope map), geological substrate and land use were introduced (Dobre 2009). Thus, in the framework of the multi-criteria analysis, each factor was given a different weight.

Each map was analysed and given a suitability value from 1 to 10, where 1 represented a suitable area and 10 an unsuitable area. The slope map was reclassified into four classes of road infrastructure development suitability and normalized in ILWIS as follows: slopes below 10% were given the value 1 (as such slopes are considered highly suitable for road network development), slopes ranging between 10-20% were given the value 5 (these areas are thought to have an average suitability, as they require complex road structures, e.g. embankments) and slopes over 20% were given the value 10 (such areas are deemed unsuitable, as they require highly costly road structures, e.g. tunnels).

In terms of terrain suitability, the geological factor plays a key role through structure friability and the close connection with the present-day processes that can affect the high-speed transport infrastructure in the post-construction period.

The vector dataset with geological data was simplified in the sense that the rock areas with similar characteristics were joined. Therefore, several areas resulted, which were given different suitability values (see table 2). Sedimentary rocks were given the value 2, as they are favourable to human activities.

Table 2. Suitability values for geological data

Geological data	Suitability values
Sands, gravel and leossoid deposits	2
Tarcău facies and flysches	5
Flysches, sandstone and conglomerate facies	5
Flysches and Inocerami layers	5
Sandstone, grey and red marl, gypsum	9
Breccia, salt, gypsum, marl, sandstone (Hârja layers)	9
Grey marl, sandstone	9
Clay, breccia, salt	9

Sturdier rocks such as flysch and sandstone formations were given the value 5, as they increase the difficulty of human activities. Finally, hard rocks alternating with marls or clays were given the value 9 (unsuitable), as they can trigger landslides.

The land use map offers an overview of the areas suitable for the development of the transport network. In the framework of this analysis we used the Corine Land Cover 2012 dataset. The normalization process was similar to the above-mentioned factors, with suitability values from 1 to 10, depending on the characteristics of each element on the map. The areas covered with orchards and vineyards were considered unsuitable, as they are typically located on steep slopes, the areas covered with forests and pastures were deemed moderately suitable and, finally, the areas covered by agricultural land and constructions were considered highly suitable, as they overlap with gentle slopes and have a high potential for road network development.

The terrain suitability map was created using the Spatial Multicriteria Evaluation module in Ilwis, with equal weights for each factor included in the multi-criteria analysis (slopes, geology and land use).

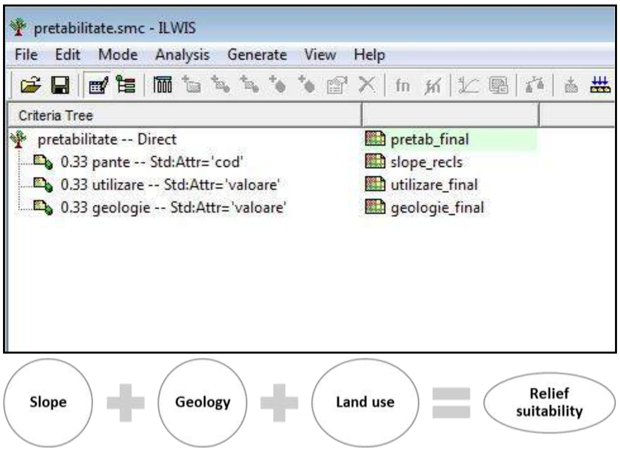

Figure 2. *Methodological scheme of the relief suitability map*

3. RESULTS

The terrain suitability map for development of man-made features, especially for the road infrastructure network, represents the weighted sum of lithological elements, geomorphologic aspects and land use data. Each of these elements have a specific impact on human activities. This kind of map emphasizes the most suitable areas for the development of human activities, specifically for the development of the transport infrastructure, based on a complex spatial and multi-criteria analysis (Dobre 2009).

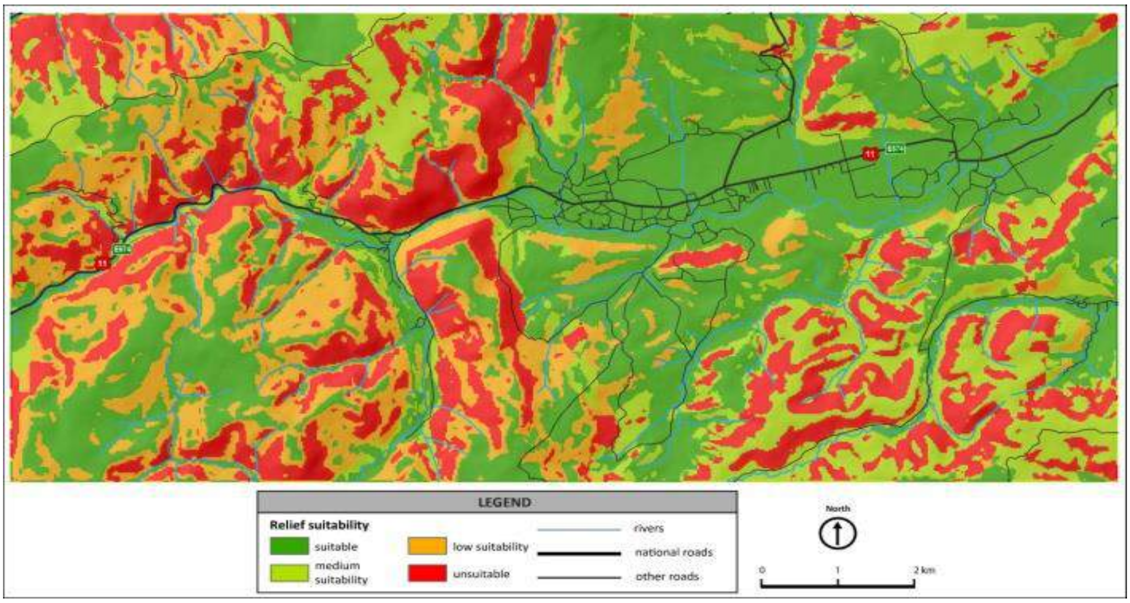

Figure 3. *Terrain suitability map*

Identifying an optimal highway route through an area where multiple restrictive factors overlap, like the Oituz gorge, can prove to be a challenging task. The relief suitability map might be of use to road administrators, by highlighting restrictive and vulnerable areas, both in the project and the construction phases of the highway network. Moreover, this kind of map can provide useful information for a further project phase, especially when planning the structures of a highway (e.g. tunnels, bridges, excavations or embarkments).

All the results mentioned above were imported in ArcGIS 10.3 for validation using the Open Street Map road data and satellite imagery.

Therefore, using all the road infrastructure data and the urban areas from Open Street Map, improved with data derived from satellite imagery, we layered and intersected the obtained data with the terrain suitability map. The resulting complex index-map was validated, thus the urban areas and the road network (national, county and communal roads) being found on suitable areas (75% of the road network). Furthermore, the map revealed that only 5% of the road network is located in unsuitable areas, most of which consist of forest roads. The only national road that intersects unsuitable areas is the National Road 11/European Road 574 in the Oituz Gorge.

Table 2. Terrain suitability – results

Total area	118,72 km^2	%
Suitable	47,92	41
Medium suitability	21,43	18
Low suitability	22,89	19
Unsuitable	26,48	22

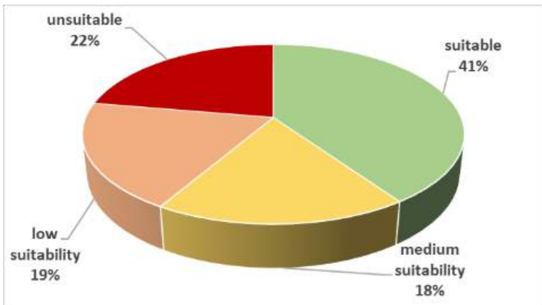

***Figure 4**. Relief suitability*

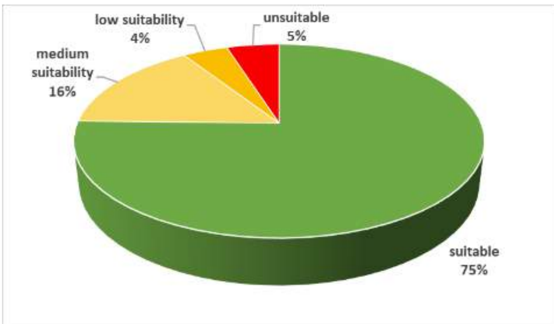

***Figure 5.** Intersection of road data and terrain suitability values*

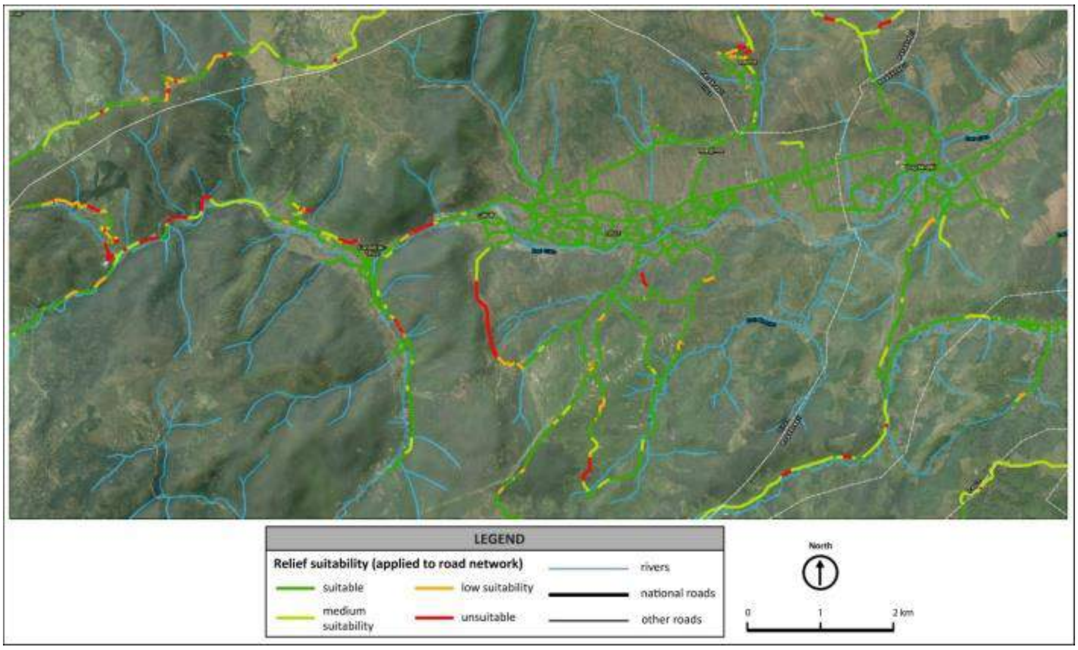

***Figure 6**. Intersection map of road data and terrain suitability*

4. CONCLUSIONS

Using the multi-criteria analysis for major road transportation projects has proven to be a useful tool for road infrastructure project preparation. This methodology can be improved by adding further spatial data regarding soil cover, social aspects and utilities (e.g. gas and water pipeline networks). The remote-sensing validation can be refined with field validation and all the results can be used for creating the most suitable highway corridors in a restrictive area.

The accuracy of this kind of analysis is ensured by the scale of data sources and by the complexity of the GIS database. By using large-scale in-field validated data, this analysis can become a trustworthy decision-making tool.

Currently, the research team is developing this methodology that can represent the basis for feasibility studies and can significantly decrease the problems that may arise both in the planning and construction phases of major road infrastructure.

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A PhD approach to assessing deforestation dynamics over two decades in two Romanian counties

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Abstract. Deforestation is an increasingly visible and heatedly debated issue in Romania. This PhD thesis aims to join the argument and accurately determine forest dynamics in two counties by comparing satellite data recorded roughly 20 years apart. Additionally, it will attempt to establish a correlation between changes in forest cover and the occurrence of extreme events. If successful, the analysis will subsequently be conducted nationally.

Keywords: *deforestation, land use, satellite imagery, extreme events*

1. INTRODUCTION

Deforestation is the process of permanently destroying forests in order to assign a new use to a given territory. The fact that deforestation (especially in tropical regions) is one of the most critical crises of our times has been stressed by various studies for decades (Ludeke, 1990; Laurance, 1999; Bradshaw, 2012).

Deforestation is a complex issue that, if studied thoroughly, can help identify areas that are prone to landslides (Kumar, 2008; Sharma, 2014) and flooding (Bradshaw, 2007; Petrișor, 2014), assess the overall state of biodiversity (Estavillo, 2013) and adjust conservation policies (Andam, 2008).

In the Mediterranean region, anthracology (the analysis of charcoal evidence found in archeological contexts) studies (Vernet, 1999) indicate, as early as the Golden and Silver Ages of the Roman Empire, the replacement of deciduous oaks by evergreen oaks, which hints to the anthropogenic disturbance caused in local ecosystems by the population's growing need for wood, widely used for housing, military purposes and as fuel, against the background of an expanding agriculture (Hughes, 1994).

Another piece of the antiquity puzzle consists of palynology (the study of pollen grains in stratified contexts, e.g. lake bottoms, caves) evidence, which shows that 1.600 years ago, after the fall of the Western Roman Empire, there were a tree pollen frequency low and a notable rise in grass pollen (Lamb et al., 1989). Lamb argues that man-caused forest degradation started roughly 250 BCE and has continued up to modern times.

Although it is estimated that 9/10 of global deforestation occurred before 1950 (Williams, 2001), the best documented period for forest dynamics began in the second half of the 20th century, following the development of satellite technology. The first satellite images that captured various regions worldwide were recorded on August 14th, 1959, by the U.S. Explorer. Later on, in 1972, the United States launched the Landsat Program, which went on to become the longest-standing teledetection program in history (ESA, 2007).

Currently, there is a wide range of rates and causes for deforestation around the world. A recent report published by the World Resources Institute shows that, in 2018, the countries with the highest tree cover loss (including due to natural fires) were Brazil, Democratic Republic of Congo, Indonesia, Colombia, Bolivia, Malaysia, Peru, Madagascar, Papua New Guinea and Cameroon, and that the tropics lost a total of 12 million ha, the equivalent of over three times the size of Belgium.

In the European Union (EU), between 1990 and 2015, forest areas increased by 17 million hectares (more than half of which were the result of afforestation programs, while the rest came from natural regeneration), i.e. almost 40% of the EU's total land area (EEA, 2015).

In Romania, even though official assessments indicate a recent increase of forest areas (MWF, 2016) of 30.000 ha between 2012 and 2016, tens of thousands of complaints were filed regarding potential illegal deforestation activities over the same period (Greenpeace, 2017).

2. STUDY AREA

This PhD thesis aims to compare satellite imagery recorded approximately two decades apart in order to establish the past and possible future forest dynamics in two Romanian counties, and to attempt to establish a relationship between deforestation and the occurrence of extreme events in the analyzed region.

The two analyzed counties, Brașov and Prahova, located roughly in the centre of Romania, are mostly made up of mountainous and hilly terrain, and total 1.437.236 inhabitants (National Statistics Institute, 2017), which places them among the country's main tourist destinations, which is consistent with their particularly active construction sector (NSI, 2017), which presumably impacts land use regionally.

Upon comparing the total area covered by the 4 forest Corine land cover (CLC) classes in the years 2000 and 2012 (Figure 1), an apparent decrease of approximately 65.000 ha can be noticed, which appears to have been followed by the aforementioned increase. However, it must be noted that there are different degrees of confidence associated to these classes: 312 Coniferous forest – high reliability (90-95%), 311 Broad-leaved forest and 313 Mixed forest – good reliability (85-90%), 324 Transitional woodland-shrub – moderate reliability (80-85%) (EEA, 2006).

Such a comparative analysis can also be helpful in determining land use dynamics within protected areas in the two targeted counties (roughly one third of the territory). Before the adoption of Government Emergency Ordinance (GEO) no. 75/19.07.2018, numerous protected areas throughout the country did not have custodians – a new national agency was created in order to address this issue – and, consequently, strict compliance with the relevant regulations could not be ensured in a uniform manner nationally.

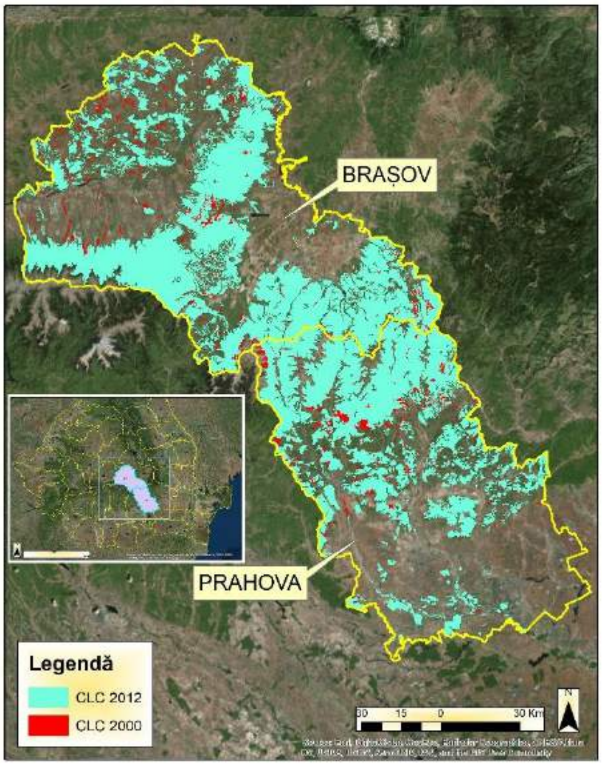

Figure 1. *Study area. CLC 2000 vs 2012 (forests)*

There are a (small) number of scientific papers tackling deforestation and its effects in Romania, two of which analyze the evolution of an urban landscape (Sinaia, Prahova County) between 1857 and 2009 using Landsat imagery, topographic maps and orthophotos (Huzui, 2011), and the changes in forested areas between 2002 and 2015 in Iezer Mountains (Argeș County, in the vicinity of Brașov and Prahova) (Mihai et al., 2017).

Additionally, in 2010, using CLC data, Dutcă analyzed land cover changes nationally between 1990 and 2006, as did Petrișor in 2014, who compared two periods, 1990-2000 and 2000-2006.

3. METHODOLOGY

The data collection and processing phases are presented schematically in Figure 2 and further details are provided below.

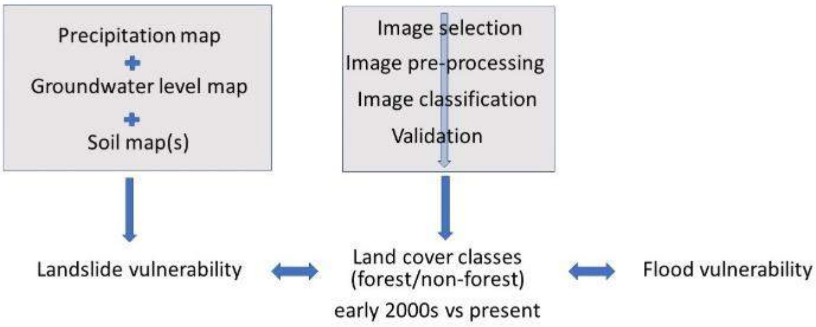

Figure 2. Data processing phases

This PhD thesis will be largely based on satellite data quality, which means the data sets will have to be carefully selected and processed. The first phase will entail an inventory of freely-available satellite data – Sentinel 1 & 2 (accessible on the European Space Agency's online platform), Landsat (via the USGS Earth Explorer platform), GOES-15 (NOAA digital library), NASA Reverb Data Hub (which grants access to data recorded by satellites Aqua, Terra, Aura, TRMM, Calipso, NASA DC, JASON, ENVISAT, ALOS, METEOSAT, GOES, ICESAT, GMS, NIMBUS, SMAP, RADARSAT) – and, if necessary, purchasing the data will be considered (e.g. GeoEye-1, IKONOS, Pléiades 1A/1B, SPOT 6/7, RapidEye).

Additionally, weather data will be collected from the National Meteorological Administration, and extreme events data from the Institute for the Study of Extreme Events.

Image pre-processing

Satellite data sets recorded in different decades can be compared once a radiometric correction procedure is applied (relative radiometric normalization – RRN) (Yang, 2000), e.g. using the Radiometric Calibration tool featured in the ENVI or ImgTools software (Souza et al, 2013), which cancels errors and corrects lighting variations (satellite recordings of the energy emitted or reflected from a surface on the ground can vary depending on the sun's azimuth and elevation, as well as on atmospheric conditions), based on a reference set.

Additionally, if the satellite recordings provide poor data due to cloud cover, a selection (masking) process will be used to generate cloud-free data (Wedastra, 2013). The sufficiently high-quality data will be selected using image quality-based band information, i.e. Pixel Reliability and VI Quality (Solano, 2010).

Image classification

The next phase will consist of classifying land use types. Similarly to Carreiras (2014) and Sulistiyono (2018), the satellite data will be processed using supervised classifications based on the maximum likelihood algorithm, which takes several factors into consideration, e.g. the probability of a pixel to be classified into classes or specific categories (Sulistiyono, 2018). Three classes will thus be created, i.e. forest cover, non-forest cover and water bodies, using a specialized image processing software, e.g. ERDAS Imagine.

Validation

The class accuracy assessment process will consist of computing the Kappa Accuracy (takes all contingency matrix elements into consideration) via an analysis based on the confusion matrix (Olofsson, 2014).

Data analysis

Land cover classes

Once the land cover classes are created and validated, the resulting images will be overlaid in order to establish the extent to which the forest cover class transitioned to a non-forest class or vice versa during the considered timeframe.

Landslides and flooding

In the scientific community, it is widely accepted that vegetation helps stabilize steep slopes (Rickli and Graf, 2009, cited in Sharma, 2014). Additionally, several factors influence the process, e.g. precipitation amounts, groundwater level, soil characteristics (Alsubal, 2019).

Based on the quality of available soil data, several or all soil characteristics – depth, inner texture, surface texture, erosion, slope, stoniness, drainage and hydraulic conductivity (Das, 2007, cited in Sharma et al, 2010) – will be mapped, as will the aforementioned factors.

The resulting maps will be superposed in order to identify landslide vulnerability in the two counties, based on a series of scores and classes that will be established at a later stage.

The study will also use flood risk maps developed by the Romanian Ministry of Environment and the Romanian Ministry of Waters and Forests, as part of the 2016 national Flood Risk Management Plan.

Finally, the landslide and flood risk areas will be compared to the resulting forest class changes in an attempt to identify a correlation between forest cover losses (should this indeed be the case) and these extreme phenomena.

4. RESULTS

This satellite data comparison-based method was used in numerous studies conducted worldwide with good results, which managed to estimate deforestation and afforestation rates, some of which were already mentioned in the previous sections. However, some shortcomings pointed out by the authors must be mentioned, e.g. the detection solely of forest disturbances that result in >25% canopy opening (i.e. low-intensity forest degradation could not be monitored effectively) (Souza, 2013, and Setiawan, 2015), data accuracy issues due to low spatial resolution and to the presence of cloud cover (even after the masking process) (Sulistiyono, 2018).

The most important and useful potential outcome of the study, in addition to obtaining a more accurate regional forest inventory (as this could help confirm or refute the official estimations), lies in possibly establishing a correlation between forest dynamics and flooding and landslide hazard, which could help guide future deforestation and afforestation practices regionally or even nationally. As such, given the scale and aftermath of some of these events (Romanescu, 2017), the results could be all the more relevant and useful to the local population, who could directly benefit from a better understanding of the consequences of current forestry practices.

As the study does not rely on the continent-wide pre-established CLC classes, of questionable accuracy, like other similar analyses conducted nationally, e.g. Dutcă (2010), Petrișor (2014), and given the smaller scale of the study, the findings may provide a clearer image of the actual land cover changes that occurred over the past two decades in the study area.

5. CONCLUSIONS

The study is intended to deliver a land cover change trajectory focused on forested areas over a two-decade period. Both deforestation and afforestation (which also includes natural transitions to forests) dynamics will be made apparent by this analysis and, based on the nature and gravity of the findings, forestry practice-related recommendations could be suggested to local decision-makers.

If successful, the analysis will subsequently be conducted nationally.

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Conference review: Water and Culture: A View from Rome, 17-18 April 2019, American Academy of Rome

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Abstract. On 17-18 April 2019, a conference was held at the American Academy of Rome (AAR) on the topic of coupling water as a hazard (floods, illness) and water as heritage, spanning from archaic (i.e. Antiquity) to contemporary design. The talks consisted of an introduction, two full sessions, a panel session on the pressing issue of climate change, and a final discussion. ENEL was one of the event-planning partners. Various fields of study were represented, ranging from design to branches of humanities and social sciences, including economics. Speakers came mainly from the USA with research fields related to Italy. Prior to the conference, a symposium on "Designing with water" was organized by the AAR, the conclusions of which were presented in the panel.

Keywords: *floods, Antiquity, rural landscapes, design, energy*

1. OVERVIEW

"Water and culture: A view from Rome" was an international conference held this spring at the American Academy of Rome in collaboration with the ENEL foundation. The American Academy of Rome is an organisation housing artists and researchers in humanities for residences in frame of the so-called Rome prize, which the name of these fellowships. Numerous countries have similar representative entities in the international city of Rome.

The conference opened with an introduction that touched on the event's rationale. John Ochsendorf from the American Academy in Rome presented how the contributions would encompass landscape, archaeology and history, but also politics, architecture and design, including dealing with extreme events and the political framework for design. Carlo Papa from the ENEL Foundation talked about the contribution of geothermal energy against the background of rising mean summer temperatures from 32 to 36°C, all while highlighting how much we can learn from history, and what architects, planners and experts can do in this field. What was presented at the conference will hopefully become common practice in 20 years, and this is detailed in the dedicated webpage section. (https://corporate.enel.it/en/futur-e)

2. FIRST SESSION

The first session was opened by Lynne Lancaster from the American Academy in Rome, who is now serving as the Andrew W. Mellon Professor-in-Charge of Humanities, and who explained that the aim of the conference was to see water and culture in both historical and contemporary times. Water management is important in order to see the cultural factors that governed human decision in the past and to tackle environmental challenges of the future. Passing from heritage to hazard, the last two talks are on disruptive water.

After the introduction, the first talk in the first session was headed by Cynthia Bannon from Indiana University, a scholar in classical studies, and tackled „Roman Water Law: Aims and Assessments. Legal rights in access to water".

Among the author's publications on the topic, there is a book titled „Gardens and Neighbors: Private Water Rights in Roman Italy (Law and Society in the Ancient World)". The speaker cited from Latona and the Lycians Ovid Metamorphosaes 6.342-3 and 6.349-51 "Why do you keep me from water" (it is common, free to all, as natural resource). Various sources for Roman Law were presented as well, such as Roman legal institutions for water, including rainwater – and the risk of damage, the special conditions on rural land; rivers and navigation, but also how the modern concept of public benefit developed (open access and the difficulty to regulate). The speaker talked about aqueducts: *pont du Gard*, *parco degli aquaedotti*, starting 312 BCE, as well as about the water flow to fountains, baths, illegal taps. An inscription found near Tivoli defines the servitude of water. Rainwater and servitude mean private water. Rivers and aqueducts mean public water.

The second talk was given by Kathy Gleason from Cornell University, a former AAR fellow in the field of landscape architecture, who addressed "Opulent Waters: Landscape Architectural Displays of Water Wealth in Ancient Rome". Water and the display of power are presented in a book published at Cambridge titled "Gardens of the Roman Empire". Several case studies are featured therein, starting with Villa Arianna at Ancient Stabiae–Castellammare di Stabia (near Vesuvius). The book analyses the implications of what was found there on water distribution in Rome. This belongs to the field of Landscape archaeology (published in *Quaderni di studi pompeiani*). There was a gentle slope for water in the ancient house. Another case study was Domus Tiberiana on Palatine Hill (with roof gardens). Hortae, the gardens of Rome's elite, were a kind of green belt around the city. Viridia was found on the porticus (on the hills, in the floodplain/campus: marshes and palace). Water was there firstly for land and production, and only secondly for entertainment purposes. Other examples included Templum Pacis, Templum Elagablus and Villa Borg, Germany, a reconstruction, as well as Palace of Kasyapa in Sri Lanka. Viridia was presented as a garden painting.

The last talk in this session was given by Paolo Squatriti from the University of Michigan, a historian who studied "Water Management in Medieval Italy". The breakdown of the Roman Empire resulted in land fragmentation in Italy. Given this context, the author wrote about peasants and social memory in a book published at Cambridge titled "Water and society in early medieval Italy", as well as in two others – "Working with water in early medieval Europe technology and resource use" and "Nature's past" – published at the university where the speaker works. First as the basis of research the findings of Karl August Wittvogel were introduced. Vatrita is a short valley between Maiale and Gran Sasso. In the 8th century it belonged to the Duke of Spoleto. Back then, Spoleto belonged to the reign of Longobards, the capital of which was Pavia, to which reference is made in the presentation in the context of privatisation. A second example is Bassa Milanese in the high Middle Ages. Today, there are rural parks here. Peasants near Pavia on the banks of Ticino are presented in the context of hydrological labour of rural communities on *naviglio grande*. Turning back to Wittvogel, this can be called hydraulic despotism.

3. SECOND SESSION

The second session was opened by Katherine Rinne from the California College of the Arts with a talk titled "Trickle Down Theory in Late Renaissance and Baroque Rome", which focused on the water supply of fountains in Rome and thus on water which flows continuously, and on how water is used. The speaker is an architect, director of *Aquae Urbis Romae* (waters of the city of Rome), a web-based project developed for 20 years (started in 1998) that features a cartographic resource for over 2800 years of Rome water history (http://www3.iath.virginia.edu/waters/). In 2010, a book titled "The Waters of Rome: Aqueducts, Fountains, and the Birth of the Baroque City" was published on this topic. After the Middle Ages came the Illuminism, and, with the discovery of manuscripts, the Popes wanted to renovate the aqueducts. However, the speaker focused on everyday life and utilitarian uses.

The second talk was given by Greg Aldrete from the University of Wisconsin, Green Bay, who took on "Floods in Ancient Rome: The Eternal City Goes Under". The speaker is a history scholar (archaeology). First, Greg Aldrete investigated flood marks for 33 floods, then went on with accounts on moving by boat and closed the presentation with a photo of a surviving Roman bridge in flood in 1937. The duration and extent of floods were shown. Floods affect different buildings in various ways. A photo shows the Roman forum during the flood in 1902, and another one the round temple in early 20th century flood. Circus Maximus and similar Antique sites are situated in flood prone regions. Baths are not in flood prone regions, as they are more vulnerable, as shown on a map. A list of all the Domus in Rome was compiled. 85% were located on hills (out of almost 300). Roman Anti-Flood strategies included: fill (raise ground levels), drain (sewers), divert (canal schemes), contain (embankments – concrete walls). Why didn't the Romans do more to prevent flooding? Factors reducing Rome's vulnerability are topography, construction methods, elite housing distribution, water supply system. In 1910, the Tiber gates were completed; they had started being built after the flood of 1870. In 1902, they still had gaps, this is how the photo of that year's flood is explained in response to a question from the audience.

The last talk in the session was given on "Fascism and the Pontine Marshes". The speaker is a professor of history and history of medicine. The research focused on 20th century Italy. He talked about malaria. The Pontine Marshes are an area between Rome and the sea. The Fascists wanted to transform this area in a rural zone. A painting by A. Bocchi entitled *Malaria* is shown – this was the reason. Mussolini wanted to drain the Pontine Marshes. Hydrologically, the Pontine Marshes is a flood plain, very close to the sea level. Floods are seasonal. This was the largest project undertaken by fascists in the 1930s. The newspaper *La Stampa* writes "Pontine Marshes are Amazonia". The greatest massacre of trees in Modern Europe took place here. *Littoria*, building peripheral housing in this area was a great construction project. Continia, Aprilia, Cometia are some of the newly established localities. These are cities built for people to better live in but display fascist control and power. A demographic revolution took place in the Pontine Marshes (it was necessary to have a family). Mussolini labelled himself Italy's greatest physician. The Marshes have been dried and converted into farmland.

4. PANEL SESSION

These two sessions were followed by a panel on Water Management, Climate Change (environment), and Landscape Design featuring Julia Czerniak (Syracuse University), Annalisa Metta (Università Roma Tre), Edoardo Croci (Università Bocconi, Milano) and Carlo Pignoloni (ENEL Green Power SpA), moderated by John Ochsendorf. The topics were resource consumption: plastic bottles, nexus of water and energy, but also climate change, landscape and how they overlap with policy. The speakers were four accomplished designers and practitioners who talked 10 minutes each.

The first speaker, Julia Cseniak, presented a symposium she organised on designing with water at AAR in autumn (https://www.aarome.org/sites/default/files/pr_en/designing-water-symposium.pdf, https://designingwater.org/). Some highlights of the presentations in the first session at the symposium are: by the landscape architecture professor at the ETH Zürich Christophe Girot: a point cloud animation and sound recording of glaciers melting, a Michigan university geotextile project, a network that supported the gardens of Versailles. The symposium tackled urgent issues in our geological age– the Anthropocene. During the second session, it was shown how design matters as we are facing these global concerns, for example contaminated water: flooding, droughts and impurity. We have too many storm surges in the New York area, too little water in places with unique geomorphologic characteristics (e.g. Tel Aviv innovatively retaining water on site), and finally too highly contaminated water in Chinese cities where there is a rich legacy of farming. The third session was about technology, e.g. advanced digital modelling that allows experimentation accompanied by a garden show in the opening night of the event, visiting iconic water projects in Europe through the eyes of a designer 1. Villa of Tiberius in Sperlonga, 2. Baroque fountains (Trevi) in Rome, 3. Bagnaia – failing hydraulics is a new narrative of temporality, 4-5. Geneve –"regreening" the river turned to channel because of farming and floods with *jet d'eau*, 6. Versailles – exploring the garden's underground hydraulics, 7. Deltaworks Zeeland in the Netherlands.

AnnaLisa Metta, the first ENEL Italian fellow at AAR, from the architecture department of Roma Tre University, showed Evanescence, water, besides flowing. Water and climate change – mostly floods. Poste Urban park Rome 2018-19 is an own design of the speaker, situated in Flaminio district, which was shown. The speaker also presented a book on the shape of water. Turning to issues related to climate change "When Rome would have gone Tunis" is her project at AAR tackling of global warming. Some related projects the speaker investigated are Mosbach and Rahm in Taiwan, "water and energy", Lanzarote, fog capture in Chile to harvest rain from the clouds.

Eduardo Croci, the third speaker, an environmental economist (Universita Bocconi GREEN Lombardia), talked about urban design and decarbonisation: urban population growth; the international framework for urban sustainability – UN 2030 agenda for sustainable development 2015, UNFCCC COP21 Paris 2015, New Urban Agenda 2016 UN Habitat III Quito. Urban-rural interactions were discussed, as were greenhouse gas emissions: urban form and interactions with urban infrastructure, waste, potential of cities to contribute to global mitigation. Climate change-related risks cities are facing include rising temperatures, heat-waves, precipitation and storm impact, rising sea levels. Nature-based solutions (NBS)/green infrastructure (GI) can help against climate change via ecosystem services. The insurance value of NBS for increasing resilience was discussed: reducing damages in case of negative events, linkage between land, water and energy nexus OECD 2017; a resource-efficient, resilient, circular city.

The last speaker was Carlo Pignoloni, engineer on renewable energy with water. ENEL invests in green power around the world and in renewables in Italy: efficiency, green roofs. According to the speaker, renewables changed the world through their physical and social impact.

One of the questions was how many green roofs are needed to ensure water storing capacity. Annalisa highlighted the necessity to think globally and to act locally. Designers have to be involved in these problems.

5. DISCUSSION

The conference closed with a discussion and followed a chronology starting with the Romans. Some of the papers dealt with rural landscapes. The rights of citizens and societies were analysed in case of floods and Pontine Marshes, but also in terms of access to water. Water as a common infrastructure raises our sense of citizenship. Looking at trickle down water in Baroque – Trevi, villa d'Este, and rich people – we may conclude that there should be new patronage of water. Are some cities doing better than others? Yes, these are the smart, resilient cities. Rankings depend on indicators and weights. Some cities are doing very well (Barcelona, Milan, Vienna, Amsterdam), but they have to learn from each other. Network of cities in sustainability include e.g. ICLEI (International Council for Local Environmental Initiatives). Peer to peer experiences for learning include direct participation in city networks, definition of common standards, indicators, targets, as well as adaptation of solutions to specific contexts, e.g. for building over rivers. Let's reintroduce natural systems!