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Article

The Development of Cartographical Studies and Praxis in Montenegro

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Abstract: This paper deals with an analysis of cartographical studies, the real estate cadastre, and its practical implementation, as well as the introduction of cartography into different education modules in university-level studies in Montenegro. There is a discussion of the development, production, and creativity in the fields of cartography and real estate cadastre over time, cartographical projection, scientific results, and recent changes such as advanced computer- and satellite-based technologies, GIS, cartographical visualization, and digital cartography. The impact of these changes on cartographical studies at the University of Montenegro is considered. Particular attention is given to analyses of cartography and the cadastre in institutions, and their connection with the development of cartography teaching modules of Geography, Geodesy and Geoinformatics at the University of Montenegro. The integrated analysis also covers the results of the questionnaire and the significance of the geo-topographical and cartographical heritage of Montenegro, with the aim of carrying these out. It can be seen that the tasks solved by using maps have tended to become more complex and that the cartographical methods employed in this have been always directed towards Montenegro's most prominent and most urgent problems, including those that appear in the area of education.

Keywords: Montenegro, cadastre, geography, geodesy, geoinformatics, syllabus for cartography, cartographical heritage.

1. Introduction

The existing challenges of a practically already-formed third-millennium civilization have an essential geographical dimension. The position of the scientific and technical public – that, from being an industrial society, we have reached the phase of a so-called 'society of risk' – is more than justified. Such a society is characterized by, in addition to permanent progress and conflicts, a strong need for detailed GIS databases, especially for a geo-ecosphere, which is subject to a high degree of anthropopression (climate change and a degraded environment), followed by an inevitable increase in the number and severity of natural catastrophes.

Cartography, in collaboration with other geospatial sciences, has always dealt with various tasks concerning the detecting, collection, processing and presenting of actual data and information about geospace.

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Maps are intertwined with mankind's existence; they are "time in motion", a witness of change, and a spontaneous means of communication, an essential attribute of the development and progress of civilization. In the historical development of cartography, cartography also reflects on its own temporal development, often directed to the cartographical heritage of the particular geospace. With this understanding, the explorative character of our research was defined.

Through the many layers of analysis of Montenegro's geo-topographical and cartographical heritage, we have covered several domains in our approach: the territorial reach, the contents and the thematic and temporal framework. A refocusing has been carried out, not only in relation to geographical investigation of the geospace of Montenegro, but also in relation to the way geodata are gathered, the quality and the cartographical methods applied, the purpose of the map, and the personnel or institutions that commissioned or published the map. A qualitative basis is formed, within which the categorization of maps, their chronology, and the separate primary cartographical sources is carried out, which in the continued process enables a more advanced level of analysis of the geo-topographical and cartographical heritage of Montenegro.

2. Materials and Methods

Modern cartography in Montenegro is not only a 'specialist' science and/or method, which observes space from the perspective of its own narrow domain – that is, from the perspective of its relation to the subject – but is also a science present in all spheres of the functioning and institutional organization of Montenegrin society.

In the research procedure, cartographical activity in Montenegro is presented here using historical and cartographical methods of analysis, taking into account the authors, the importance, the content and time of production of each cartographical work. Documents that vary in rank and origin are analyzed methodologically in the framework of the existing historical, geographical and cartographical literature, the documentation of their systemic representation.

The data mentioned in the analyses is mostly cited from the following sources: Sindik, I. 1931, 1932, Šobić, D. 1953, Senđerđi, J. 1955, Škrivanić, G. 1974, 1979, Cartography (Military Institute of Geography, Belgrade – Chapters 14 and 15) 1974, Hassert, K. 1995, Radusinović, P. 1996, Il Montenegro, Da relazioni dei provveditori veneti (1687-1735) 1998, Dvorski, V. 2000, Pulević, V. 2006, Radojičić, B. 2008 and Nikolic, G. 2010.

The most important works that have been historically essential to the development of cartography in Montenegro, due to their cartographical and graphical representation and formation, are cited. A review of the cartography of modern geoscience and specialist practice is also presented, especially concerning geo-ecological mapping and its visual cartographical language, as a parallel language of the sciences and disciplines of geography, geology, ecology and geotechnics. These documents are presented separately at the end of the text in the form of a table (Table 1).

The research was also supported by a questionnaire, within which two groups of questions are defined. Those results are presented at the Questionnaire section of the Results and Discussion chapter.

3. Results and Discussion

3.1. Historical Development, Scientific Results and Cartographical Production in Montenegro

Considered retrospectively, the Montenegrin national geospace has experienced not only territorial fragmentation, but also intensive cultural, historical, and civilizational influence: from ancient times until the present day.

Montenegro, as an independent state on the Balkan Peninsula, had neither local cartographers nor an official state cartographical institution. The first sufficiently clear forms of Montenegrin cartography within the framework of the Balkans can be followed from the second half of the 18th century (Senđerđi, 1955).

Crtographical activity connected with the territory of Montenegro is conditionally divided into two parts, in which:

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- Montenegro was mapped and graphically presented, together with the neighboring regions and countries; and
- Montenegro was cartographically presented as a separate geographical and political entity.

The area of present-day Montenegro appeared very early on in geographical and historical maps. This relates to a territory which was intrinsically in the contact zone between the ancient civilizations of Greece and Rome (Peterca et al., 1974). This contributed to the earliest preserved ancient maps which include those territories that constitute present-day Montenegro. The elements concerning the physical geographical contents of this territory mostly appear as contours, and resemble a rough sketch. Two primary cartographical sources that were characteristic of this period were analyzed.

Ptolemy's geographical handbook Γεωγραφικὴ Ὑφήγησις (Geography), according to both the text and cartography, especially in the presentation of Europe (maps 5 and 9) (Škrivanić, 1974), in the 8th book of this work, shows graphically the physical-geographical territory of present-day Montenegro with sufficient fidelity (coasts, islands, rivers, mountains and settlements).

Tabula Peutingeriana, dated to the 3rd century A.D., as a cartographic work , belongs to the Roman period (Sindik, 1931). This map is characterized as having been produced for the purposes of physical geography by its representations of roads and important settlements – particularly of the coastal and central parts of Montenegro.

Major geographical discoveries in the late 15th and early 16th centuries were followed by the intense development of cartography in Italy and Venice. The present-day territory of Montenegro was presented in various original manuscripts and maps, and also on maps within the framework of various thematic atlases (Škrivanić, 1979). We have dealt with one map and three thematic atlases with a subject-based analysis.

On the map Europae Descriptio Anno 1500, Montenegro, with Cetinje shown, was represented as one of the 28 countries in Europe at that time. This map is a primary source. According to historical data, this was, apart from Dubrovnik and some parts of Dalmatia, the only free part of the territory of South-East Europe at that time (Sindik, 1932).

The atlases, made by the well-known cartographical workshop of V.M. Coronelli (1650–1718), contain cartographical representations of parts of the territory or of the whole modern-day territory of Montenegro (Sindik, 1932). The collection of the museum of the old naval town of Perast (with more than 2,000 items) contains a copy of an atlas from Coronelli's Map of Montenegro – Geographicus; together, the collection forms an invaluable treasure of Perast and offers a probable picture of the way of life for the town and the Bay of Kotor over the previous centuries.

In an atlas made by the well-known Dutch cartographer A. Ortelius (1570), Theatrum Orbis Terrarum, the territory belonging to present-day Montenegro is represented on three maps, at different scales.

One of the best-known European cartographical workshops of that time, that of G. K. Mercator, produced Atlas sive cosmographiae meditationes de fabrica mundi et fabricati figura, where the territory of Montenegro is contained in the second volume, within the framework of four cartographical and graphical presentations, and it is a similar story for many other contributions in the atlases and maps of European publishers of that time.

The complicated geopolitical situation of the region to which modern-day Montenegro belongs was particularly expressed from the mid-18th century and throughout the 19th century, beginning from the three-way confrontation between the Venetian Republic, the Habsburg Monarchy, and the Ottoman Empire, until the wars of liberation and the creation of the Montenegrin state. This was also the time when the first topographic measurements in the Habsburg lands were being made. Vienna became the most important cartographical center where, already from the 16th century, data and cartographical contributions concerning the lands of the Southern Slavs were being collected and published, including those of the present-day territory of Montenegro. The cartographical heritage of this time horizon is represented in many geographical, topographical, and historical maps (Il Montenegro, da relazioni dei provveditori veneti 1687–1735, (1998)), which belong to the Ottoman, Austro-Hungarian, French, Russian, and English schools of cartography.

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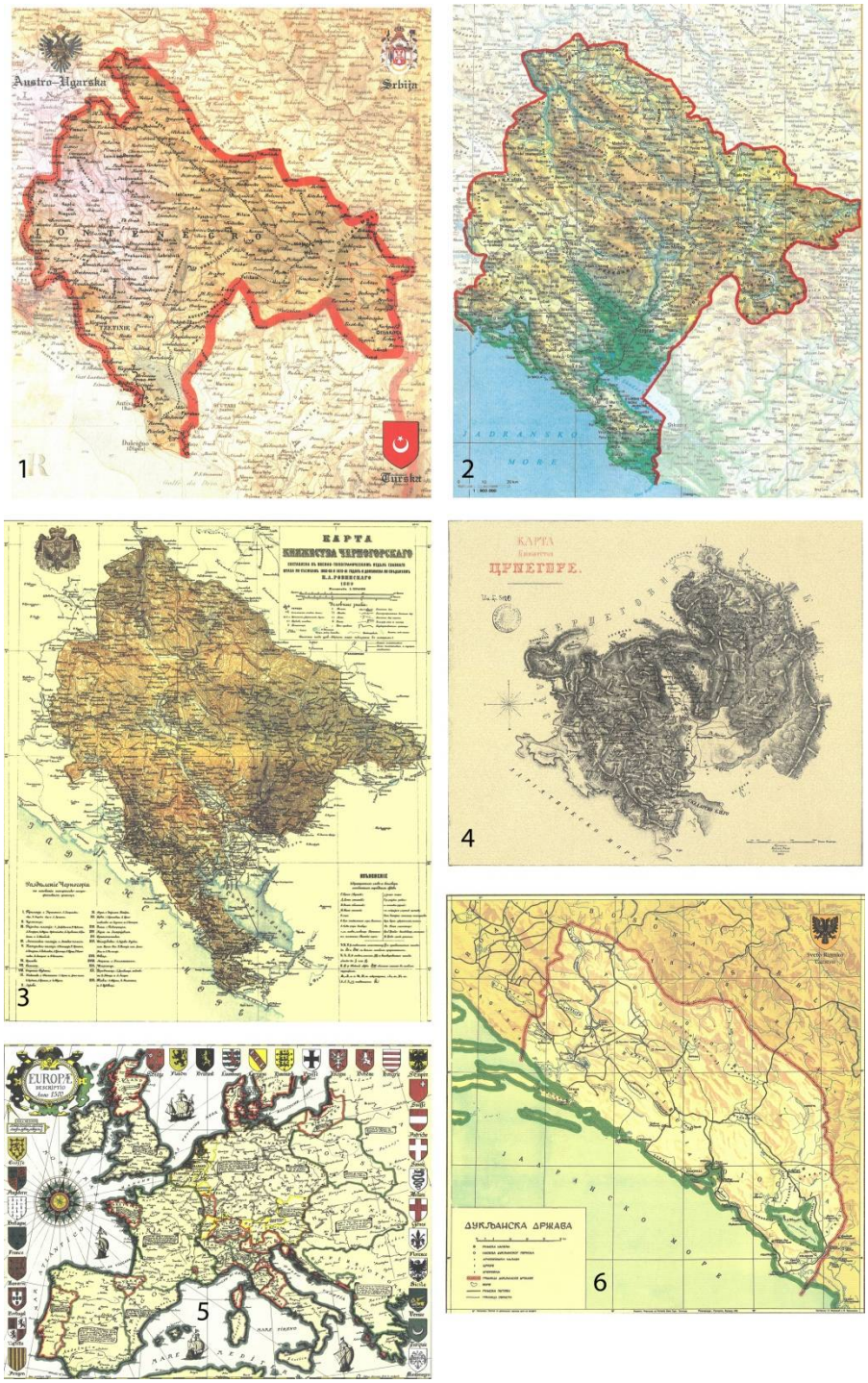

Figure 1. Overview of typical historical maps of Montenegro: 1. Map of the Kingdom of Montenegro after the Balkan Wars, which ended in 1913, until the Podgorica Assembly which formed the Kingdom of Serbs, Croats, and Slovenes (during the rule of Nikola I Petrovic); 2. Map of the Territory of Montenegro after the Second World War (1945); 3. Map of the Territory of Montenegro after the Berlin Congress, compiled by the researcher and historian, Pavel Apolonovich Rovinski, in 1889 (during the rule of Prince Nikola I Petrovic); 4. Map of the Territory of the Principality of Montenegro, published in Novi Sad by Vasoja Riza in 1853 (during the rule of Prince Danilo I Petrovic); 5. Map of European states in 1500, on the basis of Italian sources and using original toponyms. Montenegro is marked as an independent state in the Balkans surrounded by the Ottoman Empire; 6. Map of the territory of Duklja (10th-11th centuries) made on the basis of an original map produced for the history of Montenegro (map compilers: S. Markovic, P. Pelivanski, reproduced by "Geokarta", Belgrade, 1966). The original names from the Duklja period are given.

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Among them, we have singled out those maps which belong to the category of primary cartographical sources.

The map The Ottoman Empire was produced by La Rouge; it was published in Paris in 1770. The territory of Montenegro was given on sheet No. 10, where one can find Montenegro and the Bay of Kotor as an additional map.

The map Zemljo-obražanije Serpske, Bosne, Dalmacije i Crne Gore, published in Vienna in 1805, was produced by S. Popović Tekelija. This map presents the territory of Montenegro separately.

A French colonel, L.C. Vialla de Sommières, produced a map with a scale of 1:260,000 on the basis of his 'own notes when he stayed in Cetinje and travelled around Montenegro in 1809'. The map was given as a supplement in the book Voyage historique et politique au Monténégro (A Historical and Political Voyage to Montenegro), which de Sommières published in Paris in 1820.

The map of Count F. de Karacsaya (1829), Carte du pays de Monténégro (Map of the Country of Montenegro), was made with a scale of 1:288,000; this is a primary cartographical source. According to K. Hassert, it was a 'decisive step forward and a real scientific victory'. K. Hassert also cites as an important cartographical work the Map of Montenegro (Herbert, 1836), whose author is Nikola Milošev from Vasojevici (Hassert, 1995).

In 1841 in St. Petersburg, the Russian officer and diplomat, J. Kovalevski, published, in addition to his work Four Months in Montenegro, a map of the Montenegro of that time (Senđerđi, 1955).

The Montenegrin Prince Danilo in 1853 asked the Austrian officer, Vuković, to draw up a map of Montenegro. This map was never officially published, but two copies of it (scale 1:280,000) are kept in the Military Institute of Geography in Vienna; according to K. Hassert 'it is an important development in Montenegrin cartography' (Hassert, 1995).

In Southampton, the British lieutenant, Sittwel, produced Sittwel's Map of Montenegro with a scale of 1:200,000, which was published in London in 1860. A similar contribution is Carta di Montenegro, an Austrian map made by I. Paulini with a scale of 1:300,000. It was published in Vienna in 1861.

The Military Institute of Geography in Vienna in 1869 published the map, Das Fürstentum Zrnagora oder Montenegrou, with a scale of 1:144,000, which was drawn up on the basis of geodetic measurements performed when it bordered Turkey (Dvorski, 2000). This institute produced Generalkarte von Bosnien, der Hercegovina, von Serbian und Montenegro, with a scale of 1:300,000, which was published in 1876. This map used as its mathematical basis astronomical points determined in the framework of a campaign led by Šternik during 1872/73, together with Captain Milinković; framing data published during 1867/68 was used for the coastal belt and maritime region.

Thematically, during the whole 19th century, a whole series of various geographical and topographical representations appeared, which were contributed to by scientists and the authors of travelogues A. Boué (1840), B. Schwarz (1883), E. Tietze (1884), A. Baldacci (1886), and K. Hassert (1895), who were interested in the territory of Montenegro, and researched and mapped it. This was of particular interest to geologists, geographers, and botanists. Most of these cartographical contributions are now found in European archives – Table 1 (in Vienna, Prague, Rome, Venice, St. Petersburg, Berlin, and Belgrade).

Two works should be distinguished: one by Pavle A. Rovinski, Vojno topografski odjel gla¬v¬nog generalštaba (Military Topographical Department of the General Staff), St. Petersburg, 1889, and the second, Karta knjažestva Černogorskogo (Map of the Principality of Montenegro), with a scale of 1:294,000 (topographical framing with a magnification of 7, scale 1:42,000) (Radusinović, 1995).

P.A. Rovinski's map is a cornerstone for this period of the development of cartography in Montenegro. The analysis of this map shows 'topographical gaps – a term of J. Senđerđi', and an inconsistency in the contents and deviation from the actual appearance of the terrain (errors in interpreting the content on Austrian maps of that time), but P.A. Rovinski's map is the first work which was performed with a mathematical and geodetic basis – the triangulation of the entire territory of the Montenegro of that time (Senđerđi, 1955). This map represents one of the most

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important sources for analyzing the cartographical heritage of Montenegro (especially for 19th-century cartography).

The topographical basis for this map is contributed to by measurements with a scale of 1:168,000, which were performed from 1860 to 1866, with additions from 1874 to 1876. These measurements were performed by the Russian officer, P. Bikov. An important element of this map is topographical measuring and triangulation carried out between 1879 and 1881, which was performed during the establishing of the 'Montenegrin borders' following the terms of the Treaty of Berlin, as well as the additional surveying carried out by P.A. Rovinski in 1889.

In the late 19th century, the most important cartographical institution, the Military Institute of Geography in Vienna, produced several cartographical contributions for the territory of Montenegro (special topographical maps) Spezialkarte des Fürstentums Montenegro, at scales of 1:50,000, 1:75,000 and 1:100,000. At the very beginning of the 20th century this institute also produced Generalkarte Montenegro, at a scale of 1:200,000 (Senđerđi, 1955).

The first serious research studies and books about Montenegro were completed in parallel with this – especially studies into physical geography and geology, the content of which was accompanied by important cartographical contributions from K. Hassert (1895), P.A. Rovinski (1888–1915), and J. Cvijić (1899–1921) (Pulević, 2006).

The third epoch relates to the period from 1945 to 1992, and covers the period of the existence of the Socialist Federal Republic of Yugoslavia (SFRY) and this was a developmental phase for modern cartography in Montenegro. This period includes a large number of very high-quality cartographical productions in the field of topographical, thematic and atlas-type cartography, and are products of the Yugoslav school of cartography.

The most important work is certainly the realization of Osnovna topografska karta SFRJ (Basic Topographical Map of SFRY) with a scale of 1:25,000 (in two editions 1951–68 and 1969–80, two variants), as the main cartographical source for the composition of a whole series of topographical maps, as well as of other general geographical and thematic maps. This is a primary cartographical source, with very detailed and precise cartography of the geospace of Montenegro, shown on 142 topographical sheets. General maps of the Adriatic Sea were also made with scales of 1:100,000 and 1:180,000.

During this period a large number of maps were made in which Montenegro was shown as a separate territorial unit (republic), as well as being part of the SFRY.

The Republican Geological Survey of Montenegro in Podgorica published Geološka karta Crne Gore (Geological Map of Montenegro) at scales of 1:100,000 and 1:200,000, which was also followed by a geological interpreter. The Montenegrin Institute of Agriculture (G. Đuretić, B. Fuštić) produced Pedološka karta Crne Gore (Pedological Map of Montenegro), at a scale of 1:50,000. These are very significant thematic maps.

A thematic map, Geomorfološka karta Jugoslavije (Geomorphological Map of Yugoslavia), part of which covers the territory of Montenegro, has a scale of 1:500,000 (B. Radojičić, M. Burić, M. Mirković); it was published by the 'Jovan Cvijić' SANU Institute in Belgrade in 1990 (Radojičić, 2006).

A fact deserving attention is that activities were carried out at the Institute of Geography in Nikšić, through which the initial research and methodology for the thematic national Atlas of Montenegro were realized (G. Nikolic, 1999; 2010).

The Istorijsko-geografski atlas Crne Gore (Historical and Geographical Atlas of Montenegro) by academician J. Milović was published in 1990. The atlas contains more than 200 historical and geographical maps, gravures, drawings, and sketches of Montenegro collected and ordered chronologically and territorially; it shows how the modern Montenegro was formed, as well as how its cartography developed (Milovic, 1990). This atlas has great practical significance and is the most important work for a retrospective of the historical development of Montenegro's cartography.

The thematic Atlas biodiverziteta Crne Gore (Atlas of Montenegro's Biodiversity), (2002), is an original work by academicians V. Pulević, V. Bušković and G. Nikolić. The compilation of this atlas was assisted by USAID-IRD and the Ministry for Environmental Protection of Montenegro. In a

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similar way this team also produced Tematski atlas zaštićenog prirodnog predjela Trebjesa (Thematic Atlas of the Protected Natural Landscape of Trebjesa) (2004), for the requirements of the Environmental Protection Service of the Municipality of Nikšić. This is the first collection of maps (on CD) which deal with the problem of protection of natural landscapes in the form of a GIS atlas.

Geografsko istorijski atlas (Geographical Historical Atlas) (2003) by academician M. Burić, with the technical assistance of G. Barović, offers an overview of the development concerning the Montenegrin state from its origin (6th and 7th centuries) up until the most recent times (Barovic, 2015).

Two more important thematic atlases appeared, whose editors were the academician M. Burić and the Academy of Science and Arts of Montenegro (CANU): Atlas voda Crne Gore (Atlas of the Waters of Montenegro) (2010) and Pedološki atlas Crne Gore (Pedological Atlas of Montenegro) (2014).

The Nacionalni atlas Crne Gore (National Atlas of Montenegro) (D. Šehić, ed. G. Nikolić), published in 2005, was the first attempt to undertake activities concerning a national project of such importance. Nevertheless, it is necessary to point out that Montenegro lacked its most important cartographical work – a National Atlas of Montenegro (Nikolić, 2010).

By proclaiming Montenegro an ecological state (on 21 September 1991) the conditions were created for the publishing of a large number of cartographical works over the following two decades. These works are of fundamental importance to thematic mapping, especially in the fields of geoecology and the environment.

Durmitor National Park – the Map of Environment Protection (1:50,000) and Map of special preserves on the park's territory, of the existing state, the purpose of areas, the plan of usage, areas and spatial organization, the protection plan and regime of spatial usage and the plan of traffic and technological infrastructure (1:25,000);

Biogradska Gora National Park – Current state; purpose of areas, projection; purpose of areas, zoning plan, protection regime and technological infrastructure, map of the valorization and categorization of natural elements of the park and the wider zone, vegetation map, survey map of forest function (1:25,000);

Lake Skadar National Park – Environmental protection map (1:25,000);

Lovćen National Park – Environmental protection map, potential vegetation map (1:25,000) and Locality capture plan (1:5,000).

In the framework of the activity of the National Commission for Solving Problems Concerning Environment Quality in the Zeta Plain and the Influence of the Aluminum Plant, a set of about 20 maps was made, concerning the water-system structures, examined according to different parameters (G. Nikolić, 1992–4), with the corresponding reionization (pH, PSBs (Piralen), mineral oils, phenols, fluorides, PAHs, etc.). The scale of the maps is 1:25,000.

The state institutions which deal with producing spatial planning documentation, through Sector Study Analysis and Expertise (SS-AA), made sets of cartographical representations and graphical appendices relating to the existing state, the changes and planned interventions in Montenegro's geospace.

One of the most important documents, and a primary cartographical source is the first spatial plan of the Republic of Montenegro, which was adopted in 1986; it was amended twice (in 1991 and 1997). The spatial plan was followed by the Map of Graphical Contributions with thematic sets of maps that had a scale of 1:420,000 (Spatial Plan of the Republic of Montenegro, 1984).

The data of concern to The Yugoslav Symposium on Spatial and Urban Planning in Seismic Conditions (1982) were of no lesser importance, in particular because they dealt with the methodological problems in producing seismic maps for the territory of Montenegro. In addition to the Maps of Earthquake Epicenters over various time periods, of particular importance are the Maps of Seismic Risk, Maps of the Thickness of the Earth's Crust on the Territory of the Socialist Republic of Montenegro, and the Seismo-Tectonic Map of the Socialist Republic of Montenegro. The scale of these contributions is 1:500,000.

After 21 May 2006 and the decision by Montenegrin citizens to live in an independent state, the two most essential acts were adopted: the new Constitution (2007); and the Spatial Plan of Montenegro to2020, adopted in March 2008.

The Spatial Plan of Montenegro, in the form of the Map of Contributions, contains about 30 cartographical and graphical contributions, on which its content is thematically represented. Of these, 15 maps belong to the category of general cartographical contributions, having scales of 1:900,000 and 1:1,000,000. These contributions in the geo-ecological analysis may serve as input information only. The cartographical contributions with scales of 1:200,000 and 1:100,000, on which the existing and planned states of the spatial development of Montenegro are presented, together with contributions for the purpose of basic studies, are the GIS baseline and the basic cartographical sources and baselines used in the geo-ecological studies and analyses (Spatial Plan of Montenegro to 2020, (2008)).

On the basis of the Law on Spatial Planning (Official Gazette of Montenegro 51/08), a Rulebook on the detailed contents and format of planning documents, as well as on the criteria for land use, elements of urban regulation, and standardized graphical symbols was adopted. The rulebook contains a textual section with 131 articles defining 11 thematic areas with 357 graphical symbols.

Within the framework of international and specialist projects and expert studies, geospatial databases were specially produced with sets of important thematic maps and a topographical/cadastral basis. This is also a reason why we covered these in this analysis.

There were no direct war operations on Montenegrin territory during the breakup of the former Yugoslavia. However, along the separation zones (the western and north-western borders with the Republic of Croatia, the north-eastern and eastern borders with Kosovo and Metohija and with Albania), as well as in the NATO Corridor Zone from 1999, and also where there remained unexploded lethal ordnance from the previous wars (the territorial waters of the Bay of Kotor), there was a need for systematic surveying of areas where mines had been laid in Montenegro and in the use of remote-detection methods and GIS in this area.

In order to set up the project, analog and digital baselines were used (with rasters specially made for the areas included in projects), where the range of scales were from 1:5,000 to 1:1,000,000. The topographical maps used have scales of 1:200,000, 1:100,000 and 1:50,000, geo-referenced in the UTM coordinates system (Nikolić, 2010).

The ITF (International Trust Fund) of Slovenia and the JRC (Joint Research Center) donated Landsat satellite frames for the areas of the former Yugoslavia (1:100,000), which have been mostly used as a good basis for making and modernizing topographical maps.

Thanks to the results of such activities, the contaminated areas on the land part of the Montenegrin territory have been very successfully cleaned up (the area with suspected mines covered about 300,000 m2); the same activities also took place in coastal areas, around the Prevlaka Peninsula (an area of about 500,000 m2, depth 50 m), Mamula Island, and Verige Strait.

The project CORINE Land Cover for Montenegro was realized during the period 2005–6 as part of the Project CLC2000 for Serbia and Montenegro. The collected data was presented on maps with a scale of 1:100,000, with the corresponding database for three time epochs – 1990, 2000, and 2006.

The Montenegrin Academy of Sciences and Arts (MASA) and Academy of Sciences of Albania carried out a joint project named Regulation of the Waters of Lake Skadar and the River Bojana. The framing of Lake Skadar was performed by each party on its own territory following a joint project prepared by the Institute of Hydrometeorology and Seismology of Montenegro. The main project task was to make a digital model of the Lake Skadar bed and of the shores within the littoral belt. For that purpose, bathymetric measurements of the lake's aquatory and aerial photogrammetric survey of the shores were carried out in the period 2007–9.

On the basis of the obtained model, 29 map sheets were produced, in which the maps are shown as an atlas; the scale is 1:10,000, the total area of the lake region and littoral belt is 402.5 km2 .

In 2008, the Real Estate Authority of Montenegro made the first Digital Map of Montenegro, with a scale of 1:260,000. This map was updated in 2009, as its second edition, and on the reverse side of the map there is a series of photographs with motifs of Montenegro.

Thanks to a donation from the Japanese Government in 2007, it was possible to start constructing the Digital Topographic Map with a Scale of 1:25,000. In 2015 the activities on this project were completed, and the marking of maps with symbols, as well as the production of the infrastructural spatial data of the topographical and cartographical baseline according to the existing data model, were finished.

Under the auspices of EuroGeographics (of which Montenegro is a member), and in cooperation with the member countries of the European National Mapping and Cadastral Agencies (NMCA), the Real Estate Agency is working on improving the datasets for: EuroBoundaryMap (administrative and statistical units, with a scale of 1:100,000), EuroGlobalMap (a topographical dataset with a scale of 1:1,000,000), EuroRegionalMap (a topographical dataset with a scale of 1:250,000) and other thematic maps.

3.2. Real Estate Cadastre and its Maintenance on the Territory of Montenegro

Valuable historical data from the Skadar Cadastre, the land register of Tuzi from 1330, the cadastres of Ulcinj and Bar from 1416–7, Kotor's cadastre from 1430 and the cadastre of Donji Grbalj and Gornji Grbalj from 1439, provide evidence that the establishment of a land register in Montenegro began almost 700 years ago. The land cadastre for Gornja Zeta, the territory covering central and northern parts of present-day Montenegro, was mentioned in the documents of that time, and can be found in various charters and the Ottoman cadastral lists known as defters.

The territory now belonging to Montenegro, but which was under Austrian rule in the 19th century, was included as early as 1816 in the preparation for surveying and the formation of a land cadastre. For this purpose a framework triangulation was carried out and a grid of points was formed with a density not exceeding three points per square mile (this corresponds to linear lengths of about 5 km between points). The grid of trigonometric points contained points of orders I, II, III and IV (graphical triangulation).

The detailed measurement of territorial units, some of which were referred to as tax municipalities or cadastral municipalities, was done following the graphical method (geodetic datum). The map scales are: 1:720; 1:1,440; 1:1,452; 1:2,880; 1:2,904; 1:5,760; and 1:5,808.

The first geodetic works with geodetic instruments were carried out in 1818 by the Austrians, who developed triangulation points in the District of Kotor, which was then part of Dalmatia. The first geodetic instrument in Montenegro (at that time) – a theodolite was given to Njegoš in 1844 as a present by Baron Johan August Turski, the Governor of Dalmatia.

In Cetinje in 1855, the General Land Code was adopted, which initiated the formation of a cadastral census for the purpose of making an inventory of movable and immovable property. There were two copies of the cadastral register. One of them, which was in the Captain's Court, was regularly used and regularly updated in order to correspond to the actual situation on the ground; the other one was kept in the Senate's archives. In the cadastral register, the areas of arable land and of vineyards were expressed in old units: one ralo is equal to 1,825 m2, one kosa to 3,650 m2. One unit also commonly used was the čerek, equal to a quarter of a ralo, or 456 m2.

Land surveying using modern methods was introduced to Montenegro in 1910. Measurements were carried out according to the Prussian Code by using orthogonal and tachymetric methods, as was done up until the 1970s elsewhere in Europe. It was based on a trigonometric grid of all four orders and details were taken from a polygonal grid. The maps were drawn on card-paper with scales of 1:500, 1:1,000 and 1:2,000. The scales for town (city) areas were large, while for villages and countryside the scales were small. Measurements were initially made in urban areas, and by the time of the Balkan Wars they had been completed in Bar, Ulcinj, Nikšić, Danilovgrad, Kolašin, Virpazar, and Rijeka Crnojevića.

It is interesting to note that on 30 March 1910 in the Kingdom of Montenegro a document – the Rules and Regulations for the Buildings Cadastre – was adopted. Following these rules, urban plots and urban parcels were surveyed in Virpazar, Rijeka Crnojevića, Danilovgrad, Nikšić, Kolašin, and other places. For these urban areas, a Buildings Cadastre and property registers were formed. Measurements were carried out using the orthogonal method at scales of 1:500, 1:1,000 and 1:2,000.

420 Table 1: Cartographical works on which the present-day territory of Montenegro (from the 18th century to 2015)

Map title	Author	Scale	Country / Origin	Place and Year of Publication	Epoch
The Ottoman Empire	Le Rouge	-	France	Paris, 1770	I
Kingdom of Bosnia and Herzegovina - Rama	Schiemeck Maxmilian	1:430,000	Austria	Vienna, 1788	
General Map of Rumelia, Morea and Bosnia	J. Riedl	1:1,900,000	Austria	Vienna, 1812	
General Map of Illyria (part integral to Montenegro)	-	-	Austria Kriegesarchiv B IX a	Vienna, 1812	
Montenegro Map (made on the basis and observations of Col. Vialla de Sommières)	L. C. Vialla de Sommières	-	France	Paris, 1820	
Map of European Turkey	Artmanov	1:420,000	Russia	Petrograd (St Petersburg), 1811	
Montenegro Map (made in lithographs at L. Herbert's)	Nikola Milošev, Vasojević chieftain	-	United Kingdom	London, 1836	
Map of Montenegrin Lands (made on the basis of geographic observations in situ and the thorough investigations of Count F. Karaczay.	Count Fyodor Karaczay	1:288,000	Austria	Vienna, 1838	
Sittwel's Map of Montenegro	Lieutenant Sittwell	1:200,000	United Kingdom	Southampton, 1860	II
Map of Montenegro	I. Paulini	1:300,000	Austria	Vienna, 1861	
Principality of Montenegro	Heinrich Kiepert	1:500,000	Germany	Berlin, 1852	
Map of the Principality of Montenegro	Pavle Bikov	1:168,000	Russia	Petrograd (St Petersburg), 1868	
Map of Montenegro	Topographical Bureau of the General Staff	1:84,000	Russia	Petrograd (St Petersburg), 1878	
Special Map of Bosnia, Montenegro and Dalmatia	F. Handtke	1:600,000	Germany - Schlesien	Glogau, 1878	
Map of the Herzegovina–Montenegro Border Zone	Military Geography Institute	1:50,000	Austria	Vienna, 1880	
Montenegrin Tribal Boundaries (međe)	Military Cartographical Bureau of General Staff	1:100,000	Russia	Petrograd (St Petersburg), 1881.	
Map of Montenegro	Dr. B. Schwarz	1:168,000	Germany	Leipzig, 1883	
Geological Map of Montenegro	A. Baldacci	-	Austria	Vienna, 1886	

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Map of the Principality Montenegro	Pavel A. Rovinski	1:294,000	Russia	Petrograd (St Petersburg), 1889	
Communication Roads in Montenegro, Lake Skadar and River Bojana	Ling. Lelarge	-	France	Paris, 1892	
General Map of Montenegro	Dr. Kurt Hassert	1:500,000	Austria	Vienna, 1895	
Special Map of the Principality of Montenegro	Military Geography Institute	1:75,000	Austria	Vienna, 1893	
Terrain Forms in Montenegro	Dr. Kurt Hassert	1:800,000	Germany	Gotha Justus Perthes, 1894.	
Map of Serbia and Montenegro	Dr. Jovan Cvijić	1:750,000	Austria	Vienna, 1897	
General Map of Bosnia and Herzegovina	Dr. Jovan Cvijić	1:600,000	Austria	Vienna, 1900/01	
Special Map (of Montenegro), scale 1:75,000	Military Institute of Geography	1:75,000 & 1:200,000	Austria	Vienna	
Map of Montenegro	Military Institute of Geography	1:200,000	Austria	Vienna	
Section Map for Montenegro within Yugoslavia	Military Institute of Geography	1:50,000	Kingdom of Yugoslavia	Belgrade, 1928/30	
Section Map for Montenegro within Yugoslavia	Military Institute of Geography	1:100,000	Kingdom of Yugoslavia	Belgrade, 1928/30	
Basic Topographical map	Military Institute of Geography	1:25,000	SFR Yugoslavia	Belgrade, 1951/68 & 1969/80	
Topographical map	Military Institute of Geography	1:50,000	SFR Yugoslavia	Belgrade, 1966/73 & 1980	
Topographical map	Military Institute of Geography	1:100,000	SFR Yugoslavia	Belgrade, 1970/74	
Climatic Atlas for SFR Yugoslavia	Federal Institute of Hydrometeorology	1:100,000	SFR Yugoslavia	Belgrade, 1965/80	
Geological Map of Montenegro	Republic Institute of Geology	100 000 1:200,000	SFR Yugoslavia	Belgrade, 1985	
Historical Geographical Atlas of Montenegro (16th-20th centuries)	J. Milović NIP Univerzitetska riječ Nikšić	Multiscale	SFR Yugoslavia	Niksic, 1990	III
Map of Potential Environmental Polluters in Montenegro	Ministry of Environmental Protection – group of authors	1:500,000	FR Yugoslavia	Podgorica, 1994.	
Map of the Protection of Nature, Durmitor National Park	Republic Department for the Protection of Nature	1:250,000	FR Yugoslavia	Podgorica, 1995.	

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Map of the Quality of Water System Structures in the Zeta Plain, According to Pollution Parameters (PAHs, PCBs, pH…)	Ministry of Environmental Protection	1:25,000	FR Yugoslavia	Podgorica, 1993-1995	
Map of the Protection of Nature, Lake Skadar	Republic Department for the Protection of Nature	1:25,000	FR Yugoslavia	Podgorica, 1995	
Vegetation Map, Biogradska Gora	Republic Department for the Protection of Nature	1:25,000	FR Yugoslavia	Podgorica, 1995	
Atlas of Biodiversity in Montenegro	USAID-IRD and Ministry of Environmental Protection	1:200,000	FR Yugoslavia/ Montenegro	Podgorica, 2002	
Atlas of the Protected Region of Trebjesa, Niksic	Municipal Service of Environmental Protection, Nikšić	1:10,000	Montenegro	Nikšić, 2003-04	
Geographical Atlas of Montenegro (National Atlas of Montenegro)	ND Vijesti-MONDENEUF	Multiscale	Montenegro	Podgorica, 2005.	
Atlas of Maps of the Spatial Plan of Montenegro until 2020 (four thematic areas of maps for -29)	Ministry of Economic Development and Winsoft	1:200,000 & 1:100,000	Montenegro	Podgorica, 2008.	
CORINE Land Cover of Montenegro	Geological Institute of Montenegro	1:100,000	Montenegro	Podgorica, 2005-2006	
Atlas of Lake Skadar (Geodetic-bathymetric measurement)	Hydrometeorological Institute of Montenegro and Geopromet	1:10,000	Montenegro	Podgorica, 2007-2009.	
Atlas of Lake Plav (Geodetic-bathymetric measurement - prepared for printing)	Hydrometeorological Institute of Montenegro and Geopromet	1:5,000	Montenegro	Podgorica, 2009	IV
Digital Map of Montenegro	Real Estate Authority in Podgorica	1:266,000	Montenegro	Podgorica, 2009	
Geographical Atlas of the World	Department for Textbooks and Teaching equipment	Multiscale	Montenegro	Podgorica, 2010	
Historical Atlas of the World	Department for Textbooks and Teaching equipment and CID Podgorica	Multiscale	Montenegro	Podgorica,2012	

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Digital Topographical Maps of Montenegro: scale 1:25,000	Real Estate Authority in Podgorica and Government of Japan-expert team	1:25,000	Montenegro	Podgorica, 2007-2015
Digital Ortho-Photographic Maps of Montenegro (ORTOFOTO GSD 0.5m)	Real Estate Authority in Podgorica	Aerial survey scale 1:10,000 to 1:20,000	Montenegro	Podgorica, 2007-2015

Note: We decided to modify Senđerđi's epochs (Senđerđi, 1955).
Epoch I – end of the 18th century, i.e. the first sufficiently serious attempt at cartographical presentation of the territory of Montenegro.
Epoch II – from the beginning of the 19th century to 1945.
Epoch III – from 1945 to 2006.
Epoch IV – from 2006 to the present day.

After the Second World War, in Montenegro a new institution was founded – the Geodetic Authorities – on the basis of the Decision on Foundation and Jurisdiction, published in the Official Gazette of the Republic of Montenegro, No. 7, 1 April 1947.

During its first five-year period (1947–52), the geodetic service of Montenegro formed and determined, and also partially completed, the basic network (triangulation and leveling) for all works on the area of the republic, on which the country's surveys were based.

In this period there was no land cadastre for almost 122 areas of local councils in many districts. The total area of 1,320,000 ha contained about a million land parcels. For this reason a total of 741 cadastral municipalities were established by the Montenegrin Geodetic Service within the districts. In all the municipalities preparations were made, mostly for aerial surveys and aerial photogrammetry, while terrestrial surveying was only foreseen for a small number of them.

Eventually, the cadastral census, formed between 1952 and 1955, covered an area of 951,000 ha (69% of Montenegro's total territory of 1,382,623 ha).

The land cadastre, which had been formed on the basis of the detailed State Measurement and Cadastre Land Classification (1958–84), comprised an area of 230,000 ha, or 17% of the republic's territory; in fact this turned out to be a usable data source for dealing with real estate.

In the period between 1961 and 1992 photogrammetric measurements were carried out on about 49% of the territo¬ry, mostly covering urban areas. For the purpose of urban measurements, a local trigonometric grid was formed; this was integrated into the state trigonometric grid by including the coordinates of points lying within the area of the urban settlement and its wider area that had been calculated on the state coordinate system. This grid was based on the I- and II-order state trigonometric grids and is made up of triangles with sides of between 1 km and 4 km (Real Estate Authority of Montenegro, 2011).

Between 1997 and 2011, the Real Estate Authority (previously called the Real Estate Department), in the framework of several surveying campaigns, organized measurements of the WGS coordinates of more than 1,300 trigonometric points of all orders, as well as of polygonal points in urban settlements (Real Estate Authority, Montenegro, 2011). The accuracy of the horizontal positions of the points, determined using the static method, was estimated to about ±1 cm, while the accuracy of the RTK grid positioning was estimated to better than ±2 cm. With the obtained data and its later processing and implementation in the Monte Pos System, one of the most ambitious projects carried out in Montenegro in the field of geodesy – the Project of a Unique Horizontal Transformation Model for Montenegro – was brought to an end.

The Real Estate Cadastre of Montenegro is partly still in the process of being formed (for territory not yet surveyed), while the rest is undergoing permanent modernization, aimed at the formation of a high-quality national infrastructure of spatial data. In the middle of 2010 the GeoPortal of the Real

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Estate Authority was implemented; due to this, the efficient exchange of geospatial data between the host institution and users is possible. The portal is the basis of the system of the Infrastructure of Geospatial Data of Montenegro.

3.3. Questionnaire

The first group contains seven questions requiring a positive or negative answer (yes or no) and requiring the student to precisely quantify the answer on a scale with a value which relates to the course syllabus as a whole.

The second group contains eight questions, which have an accompanying set of 36 further related sub-questions. Through the choice of answers in the offered set, the students had the opportunity to give their opinion about the syllabus and the thematic units realized inside the department or outside it in other separate institutions. Through the answers to the questions, clear opportunities to act on these are obtained, priorities suggested and measures for improving individual areas of the course and the way of using the geo-topographical and cartographical heritage of Montenegro in the teaching process.

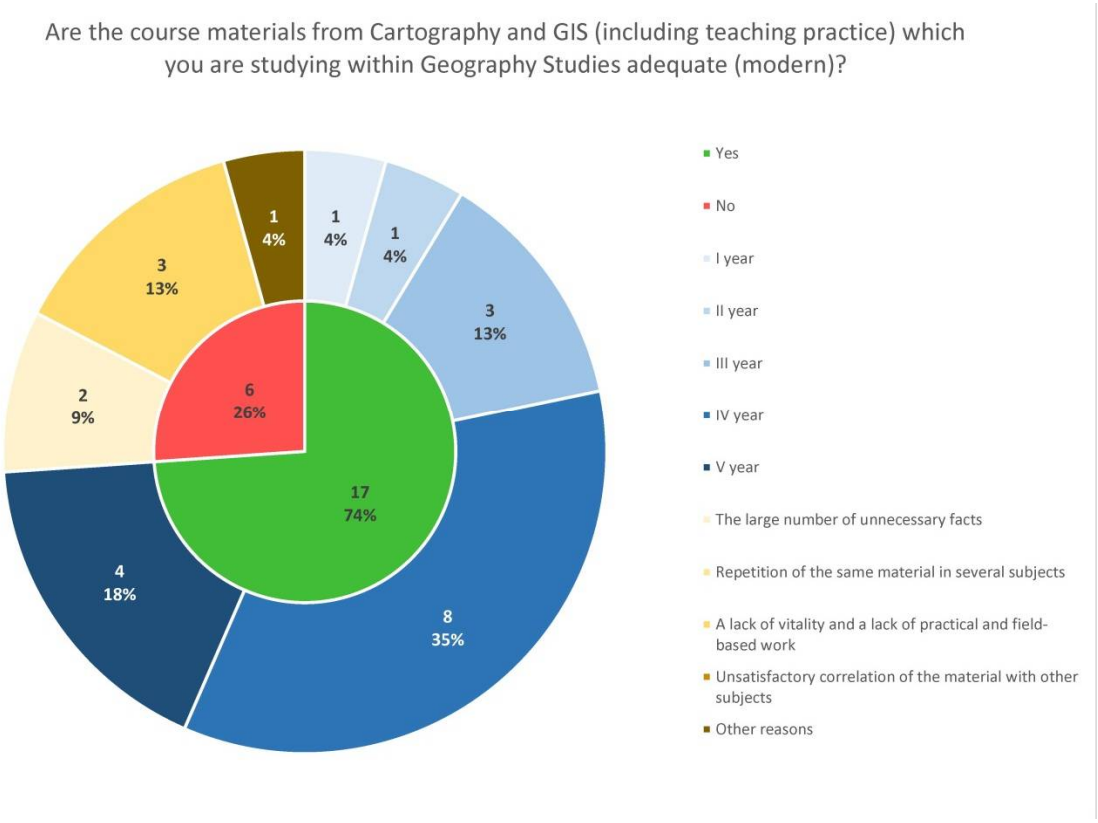

Figure 2. Survey Results – Question No.1

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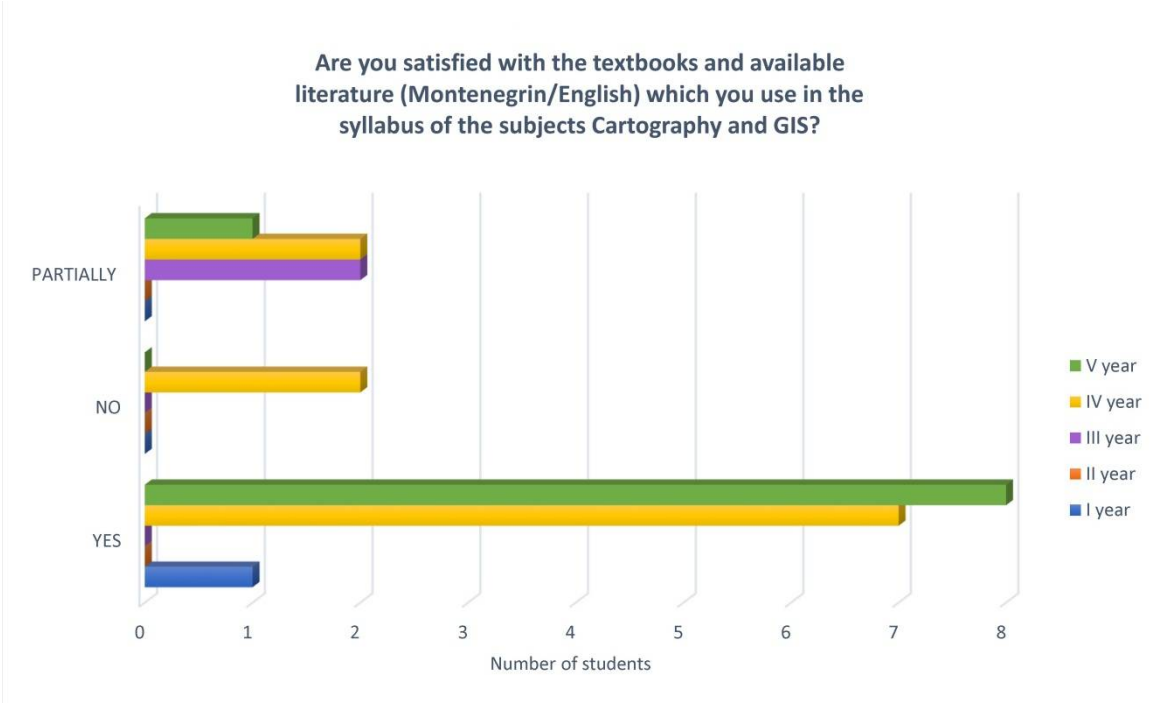

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489 **Figure 3.** Survey Results – Question No.2

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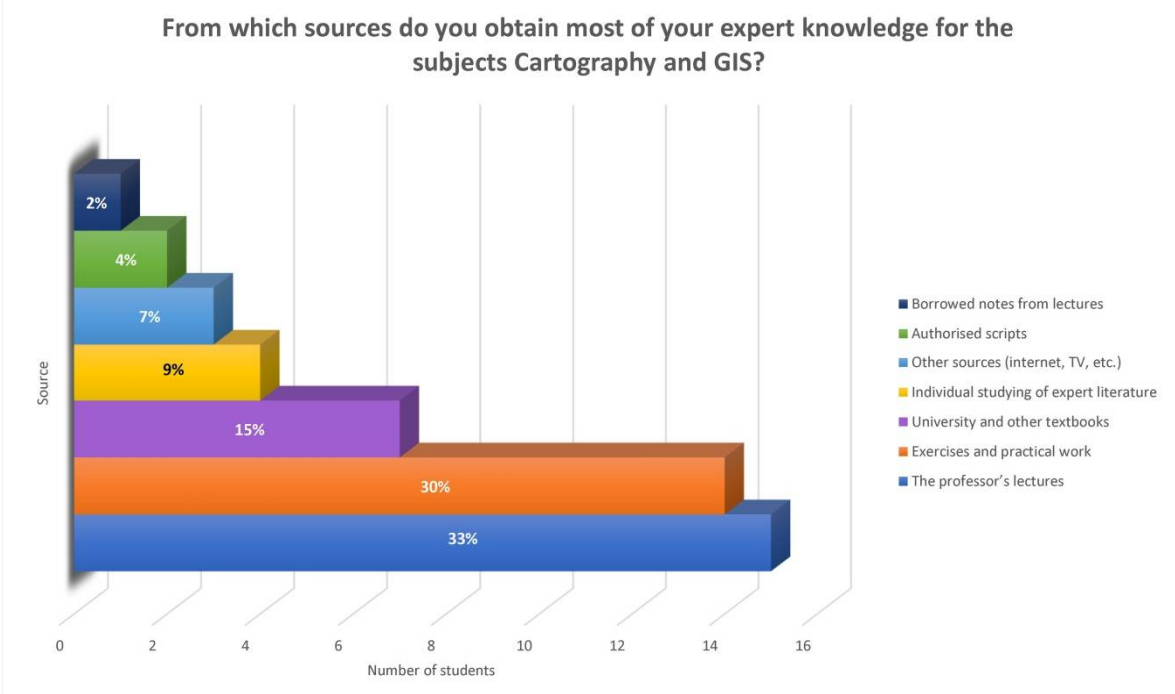

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496 **Figure 4.** Survey Results – Question No.3

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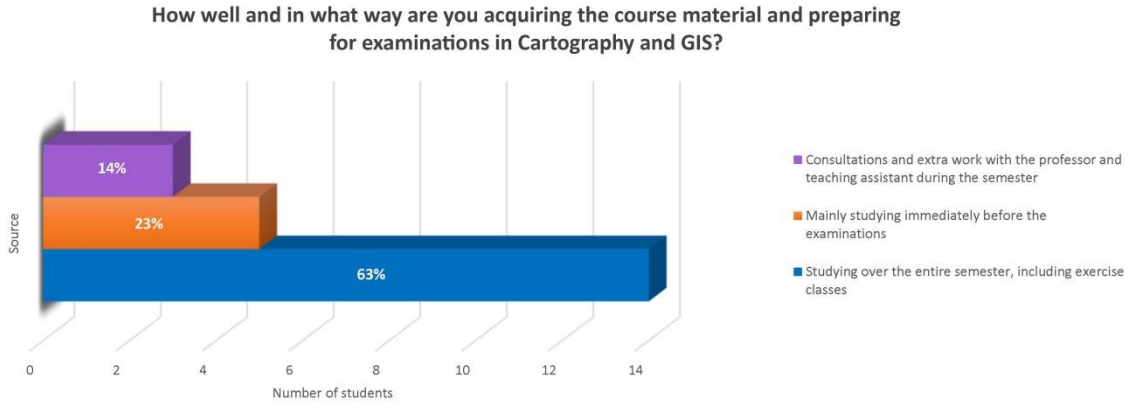

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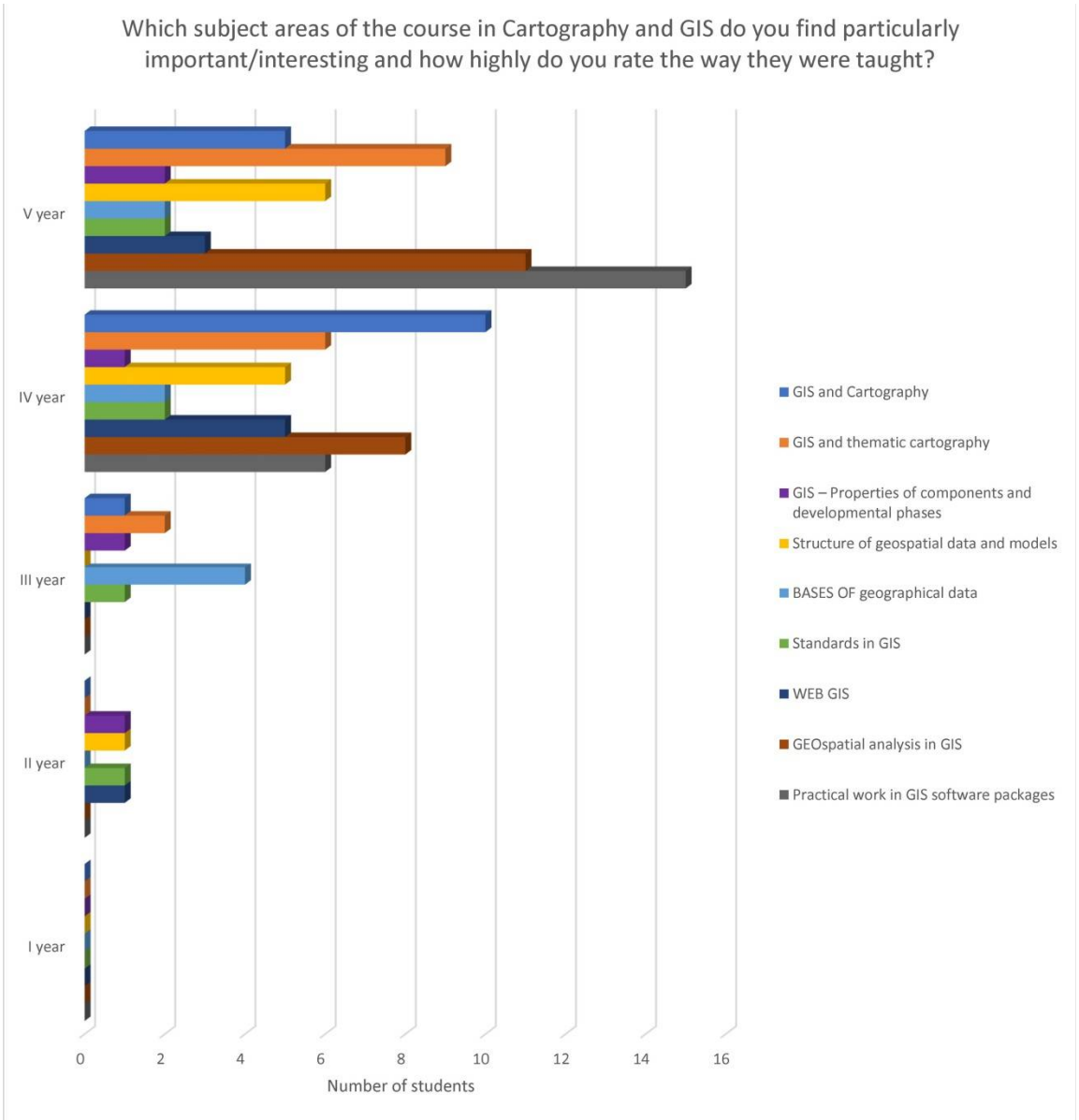
499 **Figure 5.** Survey Results – Question No.4



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501 **Figure 6.** Survey Results – Question No.5

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3.4. Cartography in the Syllabi and Curricula of the University of Montenegro

The architecture of the newly formed database of cartographical/geodetic documents and its physical production which we have presented show a clear picture of the cartographical heritage of Montenegro, the way it is integrated as a dynamic category, what role it has in the institutions of Montenegro, in their organization and tasks – particularly in the system of state management, or in the basic units of the University of Montenegro (syllabi, curricula and lesson plans, and textbooks), or at the level of international cooperation (ICA, ESA).

For almost a quarter of a century (since 1981), the syllabi and curricula of the four-year undergraduate studies at the Department of History and Geography in Nikšić have included cartography, together with the other basic disciplines of physical geography during the first year (semesters I and II), with two periods of lectures and one of exercises every week, with teaching on the field being obligatory (syllabus and curriculum of the Department of History and Geography, 2004).

In the cartography syllabus and curriculum, it is emphasized that the objective of introducing this subject is to familiarize students with the basics of cartography and its historical development, to give them a better understanding of space, geographical elements and their mutual relationship. In addition to lectures and exercises, seminar papers, consultations and fieldwork with reports are also provided as methods of learning the teaching material.

Part of the cartographical content in the framework of this curriculum is also taught to students in other basic subjects during the first or second year of studies (for instance, the thematic unit Geological Documentation within the curriculum for Geology, or Geomorphological Mapping I and II within Geomorphology) (Burić, 1987).

With the aim of harmonization with European educational standards and those of the Bologna Declaration for university education, which were adopted at the University of Montenegro, the Department of History and Geography has undergone a complete reform during, in particular during the 2004/05 academic year. Since the 2004/05 academic year it has functioned as the self-contained Academic Basic Studies, Curriculum for Geography. (Basic Academic Studies, Curriculum for Geography, 2012).

In the syllabi and curricula for the self-contained Basic Academic Geography Studies, which last for six semesters (180 ECTS credits), cartographical subjects are taught in the first and second years as basic and obligatory subjects (Basic Academic Studies, Curriculum for Geography, 2012).

General Cartography, worth 5 ECTS credits, is a subject taught in the first semester, and its structure is 2L+2E. Students also attend lectures and exercises; they have homework, seminar papers, an exam, and a mid-term test. The module takes up 150 hours (lectures: 107 hours; teaching on the field: 8 hours; necessary preparation (administration, enrolment, and semester verification): 13 hours; additional work: 30 hours).

Mathematical Geography, worth 6 ECTS credits, taught in the second semester, has a structure of 3L+2E. The module takes up 180 hours (lectures: 128 hours; teaching in the field: 8 hours; necessary preparation (administration, enrolment, and semester verification): 16 hours; additional work: 28 hours). The students' work is monitored through lectures and exercises, homework, a seminar paper, an exam, and a mid-term test. The subject is obligatory, and the most important units concern coordinate systems and cartographical projections.

Thematic Cartography is taught during the fourth semester, is worth 5 ECTS credits and has the structure 3L+2E. The module takes up 150 hours (lectures: 107 hours; teaching on the field: 8 hours; necessary preparation (administration, enrolment, and semester verification): 13 hours; additional work: 30 hours). The objective is to study the modeling and production of thematic maps and atlases in both analog and digital forms. During the first six weeks of the semester the studies cover analog thematic cartography, after which digital thematic cartography is dealt with. The exercises follow the lectures and practically they consist of producing a set of thematic maps and atlases.

Cartographical content is also taught in the framework of other basic subjects in the first and/or second year (for instance, Mathematical Geography, Geology II, Climatology with Basics of

Meteorology, Structural and Dynamic Geomorphology, Geography of Soil, and the Environment with Basics of Geo-Ecology).

Naturally, cartographical content is present in several thematic units in the framework of Geographical Information Systems (GIS), which is a basic subject during the first year (II semester), with the structure 3L+2E, worth 4 ECTS credits, and taking up a total of 120 hours each semester (lectures: 86 hours; preparation: 10 hours; additional work: 24 hours). In the framework of the semester's teaching, students deal with thematic units which include: basic knowledge about the structure of spatial data and its modeling, geographical databases and their architecture, and the updating and practical processing of GIS data; practical work on commercial and open-source GIS software packages (ESRI ArcGIS architecture), and the interpretation of different digital presentation and database software (Basic Academic Studies, Curriculum for Geography, 2012).

As for the other faculty units of the University of Montenegro where cartography is present as a separate discipline, its presence in the Geodetic Department of the Faculty of Civil Engineering in Podgorica is analyzed here –Basic Studies of Geodesy and Geoinformatics.

Cartography I and II are foreseen for the fifth and sixth semesters, respectively; the number of ECTS credits (5), the structure (2L+2E) and the total study time per semester (150 hours) are the same. According to the syllabus, Cartography I includes mathematical cartography and cartographical projection, while Cartography II includes general and thematic cartography.

Students of Geodesy and Geoinformatics also study cartographical subjects through numerous basic geodetic disciplines during all three years (for instance, techniques of geodetic measurements, geodetic surveying, mathematical geodesy, satellite geodesy, physical geodesy, geodetic astronomy, engineering geodesy, and the like). This is also the case with several thematic units in the framework of subjects covering Geographical Information Systems (GIS), which belongs to the third year (semester VI), has the structure 2L+2E, is worth 5 ECTS credits and takes up a total of 150 hours; Photogrammetry and Remote Sensing I and II, in semesters III and V, respectively, where the number of ECTS credits, structure and the total time are the same as for GIS.

It is important to say that all the study programs, and likewise the syllabi and curricula concerning cartography and geoinformatics, are now subject to reaccreditation and external evaluation (Čvorović, 2004).

The number of existing cartography textbooks for almost all levels and student profiles where it is taught as an obligatory subject at the University of Montenegro is very small. Authorized lecture texts are chiefly used, the basis for which appears in textbooks published at the University of Belgrade (M. Ljješević & D. Živković, 2001 and V. Milovanović, 1981), the University of Novi Sad (S. Đurčić, 1996), as well as the Military Institute of Geography (1974). It is very important for the development of cartographical science in Montenegro to publish cartographical works of this type, as well as other types, at the corresponding departments of the University of Montenegro. Examples of good practice are publications published for the first time by means of host institutions in Montenegro, such as: A Historical Atlas of the World, by academicians Đ. Borozan and G. Nikolić (2012), and A Geographical Atlas of the World (2009).

3.5. Montenegro's Membership of the International Cartographic Association (ICA)

Montenegro is officially a member of the International Cartographic Association (ICA). At the 14th General Assembly of the ICA which was held in Moscow on 4 August 2007, Montenegro's nomination was accepted and it became a full member of the ICA, one of the most reputable international specialist associations.

The inclusion of Montenegro in the ICA was preceded by a meeting between the representatives of the Montenegrin Cartographical Association and the ICA's president, Prof. Dr. Milan Konečný, which was held in Belgrade on 9 July 2007. At this meeting the initiative for the Montenegro's membership of the ICA was officially proposed. The initiative was particularly supported by the leading figures in the ICA, its president, Prof. Dr. Milan Konečný, and the general secretary, Dr. Ferjan Ormeling. Following their suggestion the Executive Committee initially accepted them into preliminary membership of the ICA.

The National Cartographical Association was officially formed in 2007. Its official name is the Association of Geodesists of Montenegro (Geoprogres): Cartography Division. Its seat is at the University of Montenegro, Study Program for Geodesy.

5. Conclusions

The presented historical and chronological review of cartographical and cadastral graphical databases produced for the territory of Montenegro enables us to gain, in a clear way, insight into the stages and features of the process of making an inventory and mapping data which can be used in modern geospatial analysis.

It is simply impossible to imagine any research in the field of any of these disciplines without the application of cartography and its methods. The idea and rationale for such a proposal have been reached following the positive experiences of the member countries of the European Union (Lapaine and Frančula, 2000/01).

One more matter, which is no less important, is the position that the host institution for cartography and geographical information systems (GIS) at the University of Montenegro should be the Academic Study Program of Geography. Being the host requires competency concerning acquisition of levels of positions in teaching and other fields for staff, as well as the verification and implementation of cartographical and GIS projects and/or their segments (regional and national levels) which are based on cartographical and GIS technology.

Finally, it can be noted that the tasks solved by using maps have had the tendency to become more complex and cartographical methods for these tasks have been always directed towards Montenegro's most prominent and most urgent problems.

For that reason, in our opinion it is necessary to establish within the Department of Natural Sciences of the Montenegrin Academy of Sciences and Arts, the Division for Cartography and Geomatics, which would gather together scientific and technical institutions, scientists and experts who are active in the field of cartographical, earth sciences and geoinformatics, remote sensing, and photo-interpretation.

The results of the questionnaire carried out, obtained from the opinions and attitudes that students gave on the syllabus, its educational and practical potential, which is realized more or less at the level of thematic units, confirm the necessity of the total inclusion of the database of the geo-topographical and cartographical heritage of Montenegro, that is the optimization of the ICT components and recognition of the significance of the quality of the geospatial data and coordinates among those using and providing geodata, so that their interoperability and the combining of findings from various geo-areas would be enabled.

This division would stimulate, organize, coordinate, and aid scientific and technical research within its scope. It would be involved with the following fields: archaeology and cultural and historical heritage; geodesy; geophysics; geography; geology; geo-ecology; hydrometeorology; hydraulic engineering; engineering design; oceanography; pedology; agriculture; spatial planning; forestry; and environmental protection.

Conflicts of Interest: The authors declare no conflict of interest.

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