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CONVERGENCE OF SPACE AND TIME THROUGH GIS

Abstract: Human's exploration of space has changed over time, depending on the expansion of the limits of his knowledge. Space is infinite, but it is limited by the possibility of human knowledge. The original man knew very little about the space in which he lived - about its shape, size, content, etc. Over time, the space began to take on the shapes that describe it. Those forms are its dimensions, which increased as knowledge about space increased. Knowledge spread more and more, from the Earth's surface to deep into the cosmos. Time is known to everyone, but it is difficult to define and understand. Science, philosophy, religion, art have different definitions of time, but it can be defined as measuring the progress of events. Space-time convergence explores the changing relationship between space and time. Today it is used to interpret the impact of technological progress on current world processes, especially globalization. The development of computer technology and virtual reality techniques has led to numerous changes in the representation of space. Since the initial development of computer technology, human has tried to create a virtual image of the world that he could experience with all his senses in the same way as the image of the "real" world. GIS displays data in a visual, simple and user-friendly form. The ability to transform spatial data into relevant information represents its basic value and advantage.

Key words: space, time, convergence, communications, GIS, cartography

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Introduction

The space in which human lives and which is accessible to his perception is part of the universal space which is infinite and without recognizable boundaries. But for human, it is limited by the possibility of perception and his knowledge. Space and time are experiential concepts, which change with human knowledge. It changed over time as the limits of his understanding expanded. Many philosophers have dealt with their relationship. The ancient Greek philosopher Aristotle was the first to think about the concepts of space and time, and their mutual relationship. Aristotle, summarizing earlier knowledge, formulated his views, which were respected until Galileo. Kant believed that space and time are a priori forms of sense experience, ordered systems of series of sensations (Warren, 1998; Hatfield, 2006). Martin Heidegger, a German philosopher and one of the most influential thinkers of the 20th century, focused his entire philosophical work on the "meaning of battle" - a philosophical category that denotes the totality of all that is; of what enables the existence of every being. "Historical reality and natural reality are continuities in time. Seen from the outside, history and nature are temporal...etc. (Cronon, 1992). The problem of defining space is as old as human society. Space is an experiential concept, about which various knowledges have been acquired throughout history, but even to this day there is no single definition. To define space means to give basic characteristics to the space of human action, on the one hand, and to the relationship of human to concrete space, on the other hand. Although space is infinite, it is limited by the possibility of human knowledge. Initial knowledge related to the area in which it lived, moved and hunted. According to the Philosophical Dictionary, space is "the environment in which what we perceive is located, and that is beyond the other; form of perception" (Lannone, 2013). Space can mean: spaciousness, that is, over time, one of the basic forms, the framework of all existence; the environment in which everything we see is located; limited area or volume. Originally, space was viewed as flat, with two dimensions - length and width. With the development of knowledge, the space acquires a third dimension - height. Einstein's theory also introduces a new fourth dimension, which existed as the physical quantity – time (Hlinka, 2014). Time is known to everyone, but it is difficult to define and understand. Of all civilizations, the indigenous Mayans were the most obsessed with the concept of time. The activities of the population were distributed between two seasons: the dry season, designated as the "time of the Sun", which lasted from November to April, and the season of "bad weather", the "rain", which lasted from May to October. The greater part of the year, which began with the sowing of corn, and ended with the harvesting of the harvest, was actually an agricultural period of 260 days, that's why that time was called the year Science, philosophy, religion and art have different definitions of time. Time is the measurement of the progress of events. According to the Philosophical Dictionary, "time is a form of phenomenon, the arrangement of our experiences in one consecutive series; the continuous change by which the present becomes the past; an indeterminate homogeneous environment in which events take place" (Stedman, 2003). In physics, time is one of the basic physical quantities determined by the movement of celestial bodies. Physicists define time as the progression of events from the past to the present and the future. It is not something we can see, touch or taste, but we can measure its flow (Nottale, 1996). Immanuel Kant concluded that time is a form of our "intuition". In his opinion, time is not a property of external objects, but only of the subjective mind, which is aware of those same objects. Brian Greene, American theoretical physicist, professor at Columbia University, interprets time as follows: "No one has yet found a final, fundamental definition of time, but there is no doubt that part of time's

role in creating the cosmos is to be the bookkeeper of change." We see time passing by noticing that things are different now than before". Newton believed that space and time exist by themselves, independently of the world that exists within them, and would exist even if the physical world did not exist at all (Bonnet et al., 2000). Relativistic physics views space and time as a single entity, the unification of three-dimensional space and one-dimensional time into one, four-dimensional space – time. In 1908, Hermann Minkowski presented a mathematical model of the four-dimensional continuum, which combined time and the three dimensions of space into a single four-dimensional continuum, now known as Minkowski space (Brown and Pooley, 2006).

Space-time convergence

Space-time convergence is a change in the perception of space and time. The concept of space-time convergence appeared in the second half of the 1960s. The idea of space-time convergence originates from the idea of a global village. The term "global village" was popularized by Marshall McLuhan. He visualized the world as a global village, empowered by electrical technology and the instantaneous flow of information (Ess, 2002). The concept of space-time convergence was among the first to be defined by Donald G. Janelle (professor emeritus at Santa Barbara University) in 1968. Convergence implies striving for the same goal, the property of two directions to meet at some point (Boucekkine et al., 2013). Space-time convergence explores the changing relationship between space and time, the interaction between spatial and temporal functions. Space-time is the interaction between spatial and temporal functions and the ways in which people, environments and places interact and change within them. Space and time have merged with the advancement of communication systems. Before the development of electricity in the 19th century, information could only move as fast as its transport medium. The telegraph first broke this connection, and nowadays communication is instantaneous - e.g. via e-mail, Facebook and similar platforms. Space-time convergence is used today to interpret the impact of technological progress on current world processes, especially globalization. Communication technology took off in the late 19th century, with telegraphs connecting most of the world. Further developments led to telephone networks and wireless internet, with personal devices allowing greater flexibility and access. With the progress of information and communication technology (telephones, computers, the Internet), the degree of convergence is greater. The Geographical Information System contributes to this. GIS are computer-based tools that collect, store, manipulate, visualize, analyze, manage and present spatial data. Information systems make it possible to manage knowledge, because it is considered that 70-80% of all information has a spatial component, ie. are linked for locations on the Earth's surface (Searcy and Bartlett, 1996). GIS has many applications in different fields, which are traditionally geographically related fields, for example such as urban planning and cartography, but also environmental impact assessment reports and natural resource management. Information about Earth's resources is imperative to modelling sustainable livelihoods. This requires knowledge of spatial and temporal available resources and the most effective methods of managing them.

Space and time - through GIS the past and the future are a reality

The time-geographic concept is a space-time path that follows the changes of objects, phenomena and processes through space and over time. Geographical research during the 19th

and up to the middle of the 20th century relied mainly on conventional data collected by various methods in the field. The momentum of information and communication technology has greatly reshaped the understanding of geographical space and human activities in it. Temporal geography or temporal-spatial geography is an evolving transdisciplinary perspective on spatial and temporal processes and events such as social interaction, ecological interaction, social and ecological change. Geographical space is the space of topographical, terrestrial, climatic, cadastral and other characteristics of the geographical world. Geographic information system technology is used to manipulate objects in geographic space and to acquire knowledge from spatial facts. Concepts of space and time are at the core of every GIS application. In relation to the past and the future, the present is an experiential concept, experiencing events as they happen. Spatio-temporal analysis is very important in geography and GIS: availability of large data sets (in time and space), increased management capacity, integrates, models and visualizes complex data in (near) real time. GIS provides geographic science with opportunities to integrate sophisticated spatiotemporal analysis and models into the study of complex systems. Of the several disciplines contributing to the development and use of GIS, cartography has had the strongest and greatest impact. GIS can be described as representing a 'map' of the world view, related to the notion of absolute space through time. The map is good at showing the current state of space (present), the state of space in the past (past), and predicting the movement of the state through future space (future). The convergence of space and different time periods through GIS is shown on the following maps.

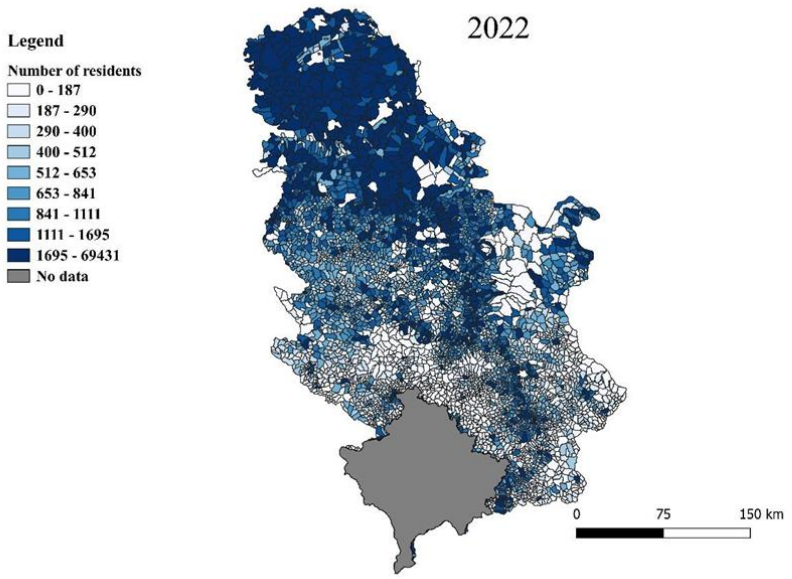

Fig. 1. Distribution of inhabitants in the Republic of Serbia according to the last census, the quantile regression (source: https://www.stat.gov.rs/sr-latn/oblasti/popis/popis-2011-2022)

One example of displaying current data is the map of the results of the last population census in 2022 in the Republic of Serbia. Map was created with the help of GIS

(Geographical Information Systems) methodology with available data by municipalities and settlements. The map was made with the support of GIS spatial analysis and three basic methodologies. The first method applied in compiling the map content was Graduated, the next was the buffer method to determine the boundary values between settlements. Finally, Zonal Statistics was used as a method to distribute the population by settlements and determine quantitative values (Valjarević et al., 2021). From the more advanced GIS methodology, spatial distribution (regression) was used, which shows the decline, that is, the real number of inhabitants per settlement (Šantić et al., 2017). In this case, GIS shows analysis through space and time, but also data in the present. Census data represent important parameters and analysis of the real state of the census area. The data show spatio-temporal convergence, by being represented through space in the present. Numerical methods and GIS methodologies significantly speed up that process and serve for a better presentation of the results (Predojević-Despić and Penev, 2016). Philosophy limits space as a time distance, but digitization accelerates the analysis of space and all elements found in space. Ancient geography developed rapidly and looked at changes through space and time, introducing coordinate systems, projections, meridians and parallels. The representation of changes in space was even more dynamic and precise.

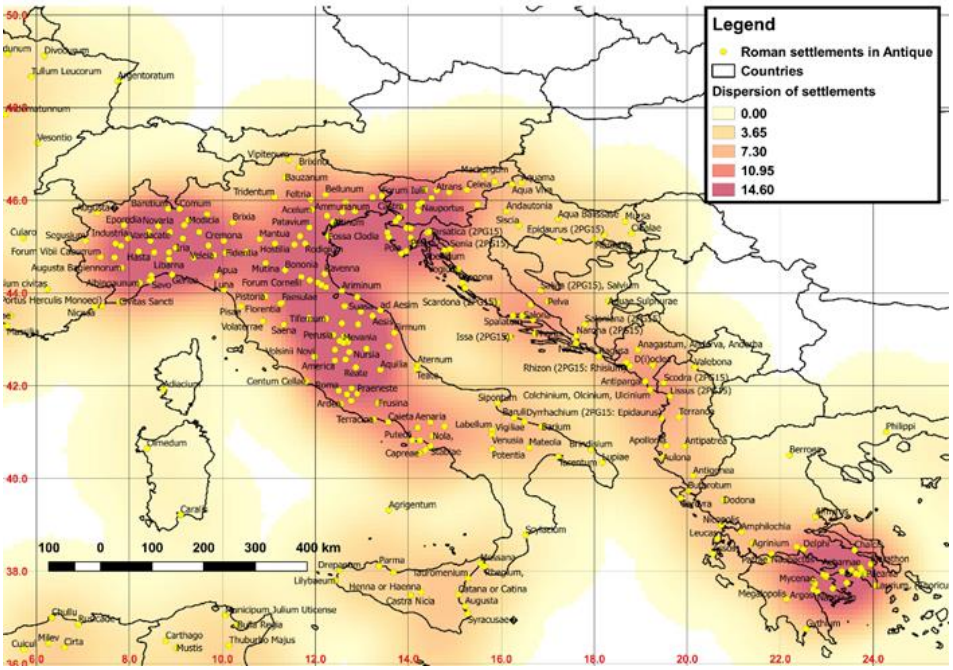

Fig. 2. The Ecumene in antiquity the area of the Mediterranean Sea (source: Valjarević, 2020)

Figure 2 shows the dispersion and position of the ecumenism in the Ancient Age. The analysis is focused on the Apennine peninsula, Greece and the Balkan countries. The map shows the situation 3000 years ago, turning space and time back. Analysing the past is important for several reasons. One is to restore the time scale and analyse all spatial changes, whether they are related through natural or social influences (Calenge, 2006). Advanced and basic GIS methods were used in map analysis. Among the basic methods, buffer methods and zonal statistics methods were used. Among the advanced methods, basic and semi-

kriging methods were used. Buffer analyses helped to define settlements and their dispersion within the Mediterranean area. Kriging methods, which are considered more advanced, are important for determining population density bands (Valjarević et al., 2023; Cattle et al., 2002). This map also reconstructed the number of inhabitants at the time of 2000 BC, so it is also important for sciences such as history, archaeology, sociology, geography, statistics, etc. (Daniels and Nash, 2004; Shen, 1999; Lovering, 1991).

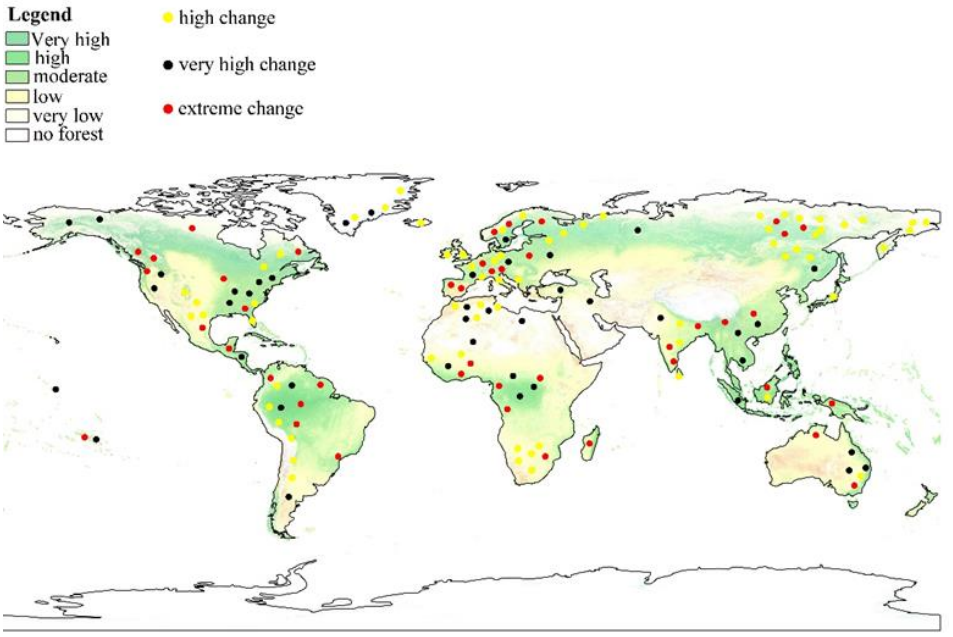

Fig. 3. The distribution of forests at the global level with the hotspots of deforestation in the future in 2050

This figure, unlike the first two maps that showed the past and the present, shows threatened forest belts in the future. The prediction was made on the basis of the IPCC (Intergovernmental Panel on Climate Change) with data for 2022. Extreme temperatures, rainfall and devastated forest zones were used (Klein et al., 2015; Waring and Schlesinger, 1985; Valjarević et al., 2022). The map was made with the help of GIS and Remote Sensing methodology. The following methods are combined: kriging semi-kriging, Global kriging, point selection, zonal statistics and point buffer. The remote sensing methods were used supervised and unsupervised pixel classifications (Ramesh et al., 2022; Muhammad et al., 2022). The displayed maps were made in the open source software QGIS (Quantum Geographic Information System, SAGA (System for Automated Geoscientific Analyses). Remote sensing methods were performed with the help of the GEE platform (Google Earth Engine). The data were renamed from free and available databases.

Discussion

There has been a lot of research on the topic of convergence of time and space. Displaying maps of the past, present, and future normalizes and presents phenomena in a geographic,

i.e., cartographic sense (Kainz, 2020). Space as a philosophical and mathematical category has great importance in all physical sciences. GIS as a modern tool accelerated geospatial analysis and thereby enabled more adequate and precise analysis of time through data series. Data, whether in raster or vector form, can be grouped and geo-databases are obtained from them, which are later used for data implementation (Stadler et al., 2009). In addition to the GIS methodology that is becoming the standard for spatial data analysis, remote sensing methodologies and procedures have been very present in the last decade. Remote sensing is very active in obtaining predictions of the future state of forests, water and soil (Li et al., 2020; Gong, 2012). Apart from the advantages of GIS and Remote sensing methodology, there are also certain disadvantages when analysing space over time. Some of them are: data availability, data accuracy, digitization process, vectorization process, data interconnection, etc. Because of all that has been said, there is a need to re-analyse and check the data obtained for the maps (Sheridan et al., 2015). In this paper, the convergence of space and time is analysed along with the analysis of the most used GIS methodology today. Research showed three different maps that showed three different time frames. The first map, on the basis of spatial and positional demographic data, showed the real (current) state of distribution, the number of inhabitants in the Republic of Serbia according to preliminary data. Thus, the current situation has shown how the Republic of Serbia should react due to the decrease in the number of inhabitants compared to the last Census in 2011. The map of the ecumenism is important not only because of the presentation of the past, but also because of the analysis of civilization in the ancient age, its distribution and the number of inhabitants. This map represents a historical and archaeological resource of civilization and its analysis is important for the future assessment of population movements. The third and last analysed map showed that predicting the future is extremely important for the protection of forests and nature. Determining the location (area) of threatened plant and animal species is very relevant today, and the prediction of the situation is even more important. The map as a basic tool of geography and GIS as a tool are very important today in the representation of spatio-temporal changes. These changes and their analysis represent the essence of all spatial sciences and disciplines. Future research on a similar topic could compare the advantages and disadvantages of GIS and Remote Sensing methodology.

Conclusion

Space and time, as experiential concepts, are known to everyone. But defining them is a big problem and they change with the spread of knowledge. Originally, space was viewed as flat, with two dimensions - length and width. With the development of knowledge, the space acquired a third dimension - height. Einstein's theory also introduces a new - fourth dimension, which existed as a physical quantity - time. Spatio-temporal convergence explores the changing relationship between space and time. Today it is used to interpret the impact of technological progress on current world processes, especially globalization. Spatio-temporal convergence explores the changing relationship between space and time and is very significant in geography. GIS provides geographic science with opportunities to integrate sophisticated spatiotemporal analysis and models into the study of complex systems. Spatial modelling with the help of basic and advanced methods is significant due to the analysis of temporal and spatial scales. In the analyses of this paper, the most important basic procedures and methods such as buffer, graduated method, zonal statistics, vectorization, georeferencing, kriging, global kriging and semi-kriging are presented. Among advanced methods, we highlight Kernel analysis, nearest neighbour street analyses, segmental buffer

and point buffer analysis, Open street maps properties. GIS together with methods in remote sensing gave satisfactory results in the analysis of space through the time dimension. Thus, the convergence of space was achieved, which is significant not only for cartography but also for all spatial sciences. In this research, three maps were presented that dealt with different time distances. The first population distribution map according to the data of the last census showed the spatial and temporal distribution of the population of the Republic of Serbia. The second map showed the distribution and density of population in Ancient Greece, i.e. the time 300 years before the New Era. Finally, the third map provided a prediction of the global forest distribution in 2050. It shows the places (zones) that would be the most vulnerable. Threats range from high, very high to extreme. Of the scientific disciplines that contribute to the development and use of GIS, cartography has had the strongest and greatest impact. Spatial convergence through GIS analysis gains speed and data availability. GIS can be described as representing a 'map' of the world view, related to the notion of absolute space through time, which is shown in the paper through maps of the present, past and future.

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

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