GEOGRAPHY'S FUTURE IS TECHNICAL

- a letter from the editor -

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Abstract
Geography has evolved from a descriptive discipline, based on exploration and mapping, to a technical and analytical science, capable of offering solutions to the complex challenges of the modern world. The transition towards a technical Geography was facilitated by the introduction of advanced statistical methods and new technologies such as GIS, remote sensing, LIDAR, UAV, etc. Autocorrelation and frequency are core concepts of the new Geography but they are common also in research from technical fields such as Engineering or Physics, which clearly proves that Geography is based on technical foundations similar to those used in other applied sciences. However, in certain states, Geography did not sufficiently adopt these tools, which led to a decrease in its relevance. In order to regain its significance, Geography must become a prospective science, capable of anticipating and manage natural and social phenomena. Universities promoting technical Geography are ready to train future leaders, while those that remain anchored in classical approaches risk becoming irrelevant. Geography's future is therefore inextricably linked to the integration of advanced technologies and analytical methods

Key-words: *GIS, Remote Sensing, LIDAR, UAV, Autocorrelation, Frequency, Antefactum science, Geographia Technica, Technical Geography, Future of Geography, Technical integration*

1. INTRODUCTION

Geography as a discipline had a significant evolution from a descriptive science, focused on the exploration and mapping of the world, to a technical and analytical science, capable of offering solutions to the complex problems of the modern world. The book edited by Goodchild & Janelle, (2004), discuss the integration of spatial analysis and technical methods into social science geography, illustrating how geography's analytical tools can solve complex problems in areas such as urban planning, environmental management, and social policy. The Dictionary of Human Geography edited by Gregory *et al*., (2009) details the historical and technical evolution of geography, describing how advancements in technology have reshaped the discipline into a science capable of addressing complex modern issues. It covers key concepts in human and physical geography that underscore this transition.

In recent years, more and more sources support the idea that Geography as a science, but also as an encyclopedia, is in a real transition from traditional mapping to a technical science through the adoption of advanced digital tools and techniques. For instance, the video segment of Penn State Public Broadcasting *Geospatial Revolution* (2024) explores the impact of these technologies on societal understanding and daily life, showcasing how tools like GIS and satellite data enable researchers to visualize spatial patterns and temporal changes globally. This digital evolution has also made geography a vital part of addressing contemporary global challenges, including climate change and resource management. The technical transformation of Geography has not only expanded its applicability into various fields, but it has also fundamentally changed the way we understand and manage the natural and social phenomena.

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In this essay, I will explore the arguments that support the claim that **Geography's future is, undoubtedly, technical,** highlighting both the discipline's stages of development and the impact of the technical methods on the research and applicability of Geography in society.

2. THE TRANSFORMATION OF GEOGRAPHY: FROM THE DESCRIPTIVE TO THE ANALYTICAL AND TECHNICAL SCIENCE

The history of Geography has started with the description and representation of the world known by maps and empirical observations. In its classic period, Geography was predominantly descriptive and it had a **postfactum role**, that is it explained phenomena that have already happened, offering retrospective perspectives on the environmental, climate and human activities changes. However, with the technological progress and development of quantitative methodologies, Geography has begun to change into an **analytical and technical science.**

At the beginning of the 20th century, Geography has started to integrate more and more quantitative models to understand the relationships between natural and human phenomena. The so-called *Quantitative Revolution* (Barnes, 2001) has set the basis of modern Geography, in which statistical methods and quantitative analyses were essential for describing and predicting spatial and temporal patterns. The book of Castree et al., (2013) provides an excellent overview of major concepts in human geography, including the historical development of geography as a discipline, the impact of the Quantitative Revolution, and the role of technologies like GIS and remote sensing.

The introduction of the *Geographic Information Systems (GIS)* and of the technologies such as *remote sensing* and *spatial modeling* represented a major technological leap, which consolidated Geography as an applied science, offering practical solutions for modern challenges.

3. THE MINIMIZATION OF THE ROLE OF GEOGRAPHY: AN EFFECT OF THE LACK OF TECHNICAL INTEGRATION

Over the last decades, in some countries and universities, Geography has suffered a *depreciation* of its role in education and society. This trend is partially the result of the perception that Geography is a discipline limited to the description of landscapes and the memorization of maps.

Lambert & Morgan (2010) explore issues in geography education across various countries, discussing how traditional teaching methods contribute to the discipline's decline in relevance. It advocates for incorporating technical skills like GIS to renew geography's appeal and importance.

In many educational systems, such as those in the United States or France, Geography has been reduced to a secondary component of social studies, losing ground to other disciplines that were more technical or oriented towards exact sciences. Bednarz *et al.,* (2013) addresses challenges in geographic education, specifically noting the lack of technical skills integration in many curricula and its impact on geography's perceived relevance in modern education. It highlights how GIS and other tools can enhance geography's role in science, technology, engineering, and mathematics.

This minimization may be directly correlated with the lack of integrating the technical methods into the teaching of Geography. In countries like Romania, Italy or Spain, Geography often remains a classical science focused on the description of the geographical phenomena without using enough technologies such as GIS or remote sensing. Without a promotion of the technical aspects, Geography risks to be perceived as irrelevant for the contemporary challenges, which leads to the decrease of interest in this discipline in schools and universities.

4. THE NEED TO TRANSFORM GEOGRAPHY IN A PROSPECTIVE SCIENCE

To regain the relevance and to respond to the needs of the society, Geography must evolve from a ***postfactum* science** to an ***antefactum* science**. A prospective approach that anticipates the geographical phenomena and provides proactive solutions, is essential in a constantly changing world.

Abler (2004) supports the idea of the need for a prospective shift in geography, emphasizing the role of technological advancements in fostering a predictive approach. Abler argues that geographers can use spatial models and data analytics to anticipate social and environmental changes. Goodchild (2010) provides insights into how GIS and geospatial technologies have expanded the role of geography into predictive and proactive realms. He discusses the potential for GIScience to anticipate and manage environmental risks and support sustainable development through real-time and predictive modeling.

The technical approaches allow Geography to become an **anticipatory science**. For example, the predictive models based on geospatial data collected via remote sensing and monitoring sensors enable the early identification of natural risks such as floods, earthquakes or climate changes and help with the efficient management of the natural resources and urban development. Technical Geography not only explains past phenomena, but it also plays an active role in shaping the future.

5. THE INCREASE OF THE TECHNICAL CHARACTER OF GEOGRAPHY. BEYOND PHYSICAL GEOGRAPHY

Physical Geography was the first branch of Geography that has benefited from the development of modern technologies. Techniques such as remote sensing and LIDAR are used to monitor the changes on the surface of the Earth, from soil erosion to extreme weather events. But this transition is not limited to physical Geography. **Land use planning** has become a profoundly technical discipline, using GIS for urban planning, infrastructure and resource management.

Jensen (2006) provides comprehensive insights into remote sensing and its applications in physical geography, including monitoring soil erosion, weather events, and other earth surface changes. It also highlights the role of LIDAR in studying landscape and environmental changes.

Human Geography and **Regional Geography** have also become increasingly technical. Batty (2013) explores the integration of GIS and spatial analysis in urban planning, discussing how geospatial technologies are essential for resource optimization, accessibility, and the creation of smart cities. This book covers technical advances in human and regional geography, particularly in urban planning. The quantitative models and spatial analyses are used to understand the dynamics of the population, the migrations, economic flows and distribution of public services. For example, in urban planning, GIS is used to optimize resource distribution, and accessibility to public services and public transport, contributing to the development of smart cities.

6. TECHNICAL FOUNDATIONS IN GEOGRAPHICAL RESEARCH: AUTOCORRELATION AND FREQUENCY

Another powerful argument for the technical direction of Geography is the integration of fundamental concepts of autocorrelation and frequency.

Many decades ago, Cliff & Ord (1981) developed a fundamental book which discusses spatial autocorrelation and its applications in geography, reactivating the ideas of Tobler (1970) and providing models and methodologies for analyzing spatial relationships. It covers spatial autocorrelation theory, essential for understanding distributions of phenomena like population and environmental patterns.

Spatial and temporal autocorrelation are essential concepts in the geographical analysis, enabling the study of how phenomena are distributed in space and time. These concepts are used in modern geographical research to understand the relationships between various spatial variables such as environmental factors, population distribution or seasonal migrations.

Fotheringham *et al.*, (2000) provide an accessible introduction to quantitative methods in geography, including spatial and temporal autocorrelation. This book explains the significance of these concepts in modern spatial analysis and their application through autoregressive models and spatial frequency analysis.

More recently Haidu (2016) argues that in addition to autocorrelation, the distribution of geographic processes and phenomena is related to spatial and temporal frequency. Autocorrelation and frequency are core concepts of Technical Geography.

Moreover, the spatial and temporal frequency is crucial for the monitoring of recurring phenomena such as climate changes or land use patterns. These concepts are analyzed using advanced tools and techniques, such as Fourier models or autoregressive models, which are common in the researches in technical fields such as Engineering or Physics.

This clearly demonstrates that **Geography is based on technical foundations similar to those used in applied sciences**.

7. COUNTRIES AND UNIVERSITIES PROMOTING TECHNICAL GEOGRAPHY

There are countries and universities that fully acknowledge the need for Technical Geography and that have adapted their curriculum to reflect this transformation.

Some universities from USA such as the University of California, Santa Barbara (UCSB) and Stanford University are leaders in geospatial research, using GIS and remote sensing for climate studies, urban planning and analysis of natural resources. Goodchild (2006) provides an overview of the development of geospatial sciences within academia, particularly in U.S. institutions like UCSB. He discusses the impact of these universities on geospatial research, especially in areas like climate studies and urban planning.

In Canada, universities such as McGill University and University of British Columbia are known for their advanced GIS and remote sensing programs, integrating Technical Geography in its academic curriculum and in environmental and resource management research.

The paper of Schiewe & Ehlers (2006) covers the advancement of GIS and remote sensing in Germany. Universities such as the Technical University of Munich (TUM) and Humboldt University of Berlin are centers of excellence in using GIS and advanced technologies for spatial analysis and Technical Geography education.

8. COUNTRIES AND UNIVERSITIES PROMOTING CLASSICAL GEOGRAPHY

By contrast, there are countries and universities that remain oriented towards the classical Geography, less opened towards integrating modern technologies.

Claval (1998), a French geographer, provides an overview of regional and humanistic geography, particularly as it has been traditionally emphasized in France. This book explains how French institutions like Sorbonne Université have historically prioritized these approaches over technical methods.

Many French universities are known for promoting regional and humanistic Geography to the detriment of Physical Geography, with an insufficient emphasis on the use of GIS and other advanced spatial technologies and insufficient attention to the mathematical modeling of geographical processes or phenomena.

In Italy, universities such as Università di Bologna and La Sapienza (Hefferman, 2003) continue to focus on classical Physical Geography, without fully embracing the technical aspects of the modern Geography. This resistance to the integration of advanced technologies limits the relevance of Geography in addressing modern problems.

Donert (2007) examined in detail the State of Geography in European higher education and his results allow us to deduce which are the European countries where classical geography remains relevant in higher education. Donert's work should be updated to see if geographic education adapts to the recent achievements of technical geography and if the new achievements are integrated or not in the training of geographers.

9. GEOGRAPHY'S FUTURE: AN ESSENTIAL TECHNICAL DIRECTION FOR THE REVIVAL OF ITS ROLE

Adopting Technical Geography is essential for reviving its role in education and society. National Research Council (2006) drew up a report which highlights how spatial thinking and GIS are essential for modern geographic education, stressing that integrating geospatial technologies can prepare students to tackle societal and environmental challenges. It advocates for a more technical geography curriculum to enhance the field's relevance. Solem *et al.,* (2008) discusses the growing need for technical skills in geography to address global challenges. It emphasizes the importance of training students in geospatial technologies, which are crucial for careers focused on environmental management, urban planning, and migration studies.

With the increase of global challenges, such as climate changes, rapid urbanization, and migration, Geography has an immense potential of providing applied solutions to improve human life and protect the environment. Geospatial technologies are the key to achieving this objective, and the universities that integrate these technologies in their research are those that will train future leaders and experts in managing these challenges.

In 2006, I created the journal *Geographia Technica*, a journal unique in its vision to publish articles from **across entire discipline** which implements technical approaches in geographical research (please see https://technicalgeography.org/index.php/aims-and-scope) and which found its place in the Wikipedia encyclopedia (please see https://en.wikipedia.org/wiki/Geographia_Technica#cite_note-tech1-1). For several years this journal has been indexed in the Core Collection of WOS, in SCOPUS and in other databases of scientific journals.

As for Technical Geography, as a new branch or discipline of Geography, the page deserves to be opened and read https://en.wikipedia.org/wiki/Technical_geography#cite_note-Haidu1-1.

10. CONCLUSION

Geography's future is, undoubtedly, **technical**. The evolution of this discipline from a descriptive to an analytical and applied science proves the importance of using advanced technologies in natural and social phenomena analysis. By adopting GIS, remote sensing, quantitative analysis, and spatial modeling, Geography becomes a central discipline in solving complex global problems. The countries and universities that embrace this transformation will play a crucial role in defining Geography's future, while those that remain attached to the classical approaches risk becoming irrelevant in addressing contemporary challenges.

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