# CURRENT TRENDS IN THE USE AND IMPLEMENTATION OF GEOGRAPHIC INFORMATION SYSTEMS

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***Abstract**: Currently, the use and implementation of Geographic Information Systems (GIS) is undergoing a rapid transformation. From the traditional way of viewing and processing geographical data through specialized desktop programs, to webGIS technology following the development of specific Web 2.0. This technology allows online interaction based on interoperability standards, also the way spatial data is presented. Thus, the integration of Artificial Intelligence, use of mobile devices and participatory GIS, the Internet of Things for real-time monitoring of environmental and anthropic components, Augmented Reality and Virtual Reality for visualizing geographic data, the increase in the use of open-source software constrain the academic community and general users to accept and adapt to these new realities. Therefore, in this article, the current situation regarding the use and implementation of GIS nowadays was assessed and consequently future trends were analysed. At the same time, a questionnaire was conducted among GIS users in the Republic of Moldova to analyse their vision with regard to the subject addressed. The identified results will contribute to the curriculum content and teaching methods enhancement of subjects taught at the bachelor and master degree at Technical University of Moldova.*

***Keywords:** WebGIS; Mashup; Leaflet; Geographic Information Systems; Volunteered Geographic Information*

## 1. Introduction

In recent years, Geographic Information Systems (GIS) have evolved far beyond traditional desktop applications to more online and user centric solutions. A major trend is the increasing use of Mashup architectures, which combine data and functionality from multiple sources, such as maps, APIs, databases, and sensor networks thus contributing to dynamic, interactive, user-friendly applications. Some of the most popular tools enabling this are OpenLayers [1] and Leaflet [2], designed for mobile-friendly interactive maps. Leaflet easy-to-use concept makes it ideal for web GIS mashups, allowing developers to integrate layers from various providers and overlay real-time or customized data.

Therefore, assessing the trends that are likely to change the way people use GIS in the near future and have the greatest impact on geospatial information management, are based on several patterns, such as political, economic, social, technological, and environmental change that will influence the state of the global geospatial industry. As the data ecosystem becomes more complex, the notion that 80 % of information has a spatial component increases the relevance of the ‘where’ [3].

Regarding Republic of Moldova, Geographic Information Systems (GIS) represent an essential technology for the analysis and management of spatial data at central and local levels. Furthermore, in 2016, the spatial data infrastructure (SDI) had been established through the Law 254/2016 regarding the national spatial data infrastructure [4], which transposes the INSPIRE Directive [5] and complementary regulations. Legal framework contributes to the delimitation of responsibilities [6, 7] and implementation of Open Geospatial Consortium (OGC) and ISO standards, at the same time provides significant to the field of spatial data and furthermore aligns with international requirements with reference to Spatial Data Infrastructure [8]. On the other hand, even the regulatory framework has been developed in accordance with the international requirements, there are major shortcomings in implementation as a result of several causes, including the fluctuation of staff involved in the process of creating spatial data sets, metadata; lack of awareness of the importance of spatial data nowadays; cumbersome implementation of innovations in the geospatial field; slow adaptation to the new realities generated by artificial intelligence, global projects based on the generation of content from voluntary geographic information, etc. Thus, this research aims to highlight the shifts caused by current trends such as Artificial Intelligence, Voluntary Geographic Information and Cloud Computing, etc. and their possible implementation and efficiency within decision-making processes.

As it was mentioned, currently the use and implementation of Geographic Information Systems (GIS) is undergoing a rapid transformation. Thus, the integration of artificial intelligence, the use of mobile devices and participatory GIS, the Internet of Things for real-time monitoring of environmental and anthropic components, Augmented Reality and Virtual Reality for visualizing geographic data, the increase in the use of open-source software have changed the way users and developers use and implement GIS. It should be mentioned that the biggest achievement is the volunteered geographic information (VGI) phenomenon that has emerged as a novel form of user generated content in recent years. VGI involves the active generation of geodata, for example, in citizen science projects, and the passive data collection via location enabled mobile devices. In addition, an increasing number of sensors perceive our environment with ever-greater detail and dynamics [9]. GIS technology is changing at very fast phase and it has move from mainframe computer to workstation and to desktop-based PC systems. With the recent advances in broadband and wireless communications technologies - as well as the dramatic increase in Internet browsing technology- promise to extend further the reach and range of GIS users working in offices or laboratories, in the field or at home [10].

## 2. Materials and Methods

The research was focused on the study of scientific articles, specialized literature, especially those developed by the United Nations Integrated Geospatial Information Framework (UN-IGIF); INSPIRE Knowledge base of the European Commission [12], national legislation and dedicated portals. The questionnaire “Current trend in using traditional GIS versus webGIS applications” was designed and applied among the community of GIS users in the Republic of Moldova with the aim of collecting relevant information and opinions on the level of use, needs, challenges and development prospects in the field. The questionnaire was distributed online, via Google Forms, to teachers, students, professionals in the field, discussion groups, during March and April 2025. The target audience consisted of specialists and practitioners who frequently use GIS tools: geographers, environmental and cadastral engineers, territorial planning specialists, academics and researchers, students in relevant specializations. The questionnaire included both closed (with predefined answers)

and open questions, covering topics such as: types of GIS programs used (proprietary vs. open-source), purpose of use, opinions on the future of GIS technologies.

## 3. Results and Discussion

Digital connectivity underpins most of the technological advances today, at the same time mobile internet access has enabled many emerging economies. Reliable digital connectivity enables advancements in Artificial Intelligence, immersive technologies, and the Internet of Things to transform how the geospatial industry captures, creates, maintains and manages data over the next decade and beyond. Moreover, future business opportunities around Big Data, analytics, Machine Learning, platform economies, digital ecosystems and smart cities are significant and geospatial information are an underpinning component of these offers [12]. Even in 2016 in the report, entitled Emerging Technologies and the Geospatial Landscape, developed by National Geospatial Advisory Committee (US) [13] highlighted specific emerging technologies in five core areas of GIS and geospatial activity, namely: data collection and generation, data analytics, infrastructure, access, and workforce. Furthermore, in the same report were described overarching technology trends that are enabling, shaping and driving emerging geospatial technologies: Real-time spatio-temporal data creation and interaction; Miniaturization of technologies; Proliferation of new mobile geospatial sensor platforms; Expanding wireless and web networks; Advances in computing speed and capacity for geospatial research and applications. According to some sources [14] one of the most important technologies in today's world is becoming artificial intelligence. This new reality is changing the perception of other ICT solutions, including GIS systems [15]. Additionally, the use of artificial intelligence and abstract spaces technologies allow for expanding the scope of applications of spatial information systems to areas that have no references in real spaces. At the moment the GIS market is experiencing significant growth due to the increasing adoption of advanced technologies such as artificial intelligence, satellite imagery, and sensors in various industries. The GIS market encompasses a range of technologies and applications that enable the collection, management, analysis, and visualization of spatial data. Key industries driving market growth include transportation, infrastructure planning, urban planning, and environmental monitoring. Remote sensing technologies, such as satellite imaging and aerial photography, play a significant role in data collection. Artificial intelligence and the Internet of Things (IoT) are increasingly integrated into GIS solutions for real-time location data processing and operational efficiency [16]. Also, ESRI identifies eight main technologies that are relevant to the development of geographic information systems and the collection of different types of spatial data, that are: Artificial Intelligence (AI), Augmented Reality (AR), Blockchain, Drones (UAV), Internet of Things, Robots, Virtual Reality, 3D printers [17]. As a result of researching the literature and dedicated portals were identified the following trends that tend to change the way GIS is developed:

1. Web GIS (also known as Web-Based GIS), that employ the World Wide Web to facilitate the storage, visualization, analysis, and distribution of information over the Internet;
2. Continuous Development of solutions for Web GIS such as: platforms, standards, software, plugins etc.;
3. VGI and crowdsourcing, trends that make it possible for anyone with a smartphone or GPS-enabled device to contribute geographic data. This breaks the monopoly that governments and large organizations used to have over geospatial data;

4. The Storytelling Phenomenon in WebGIS, that is a powerful evolution in how spatial data is communicated, from static maps and complex datasets to easy-to-understand narratives and interactive maps that connect people, places, and purpose;

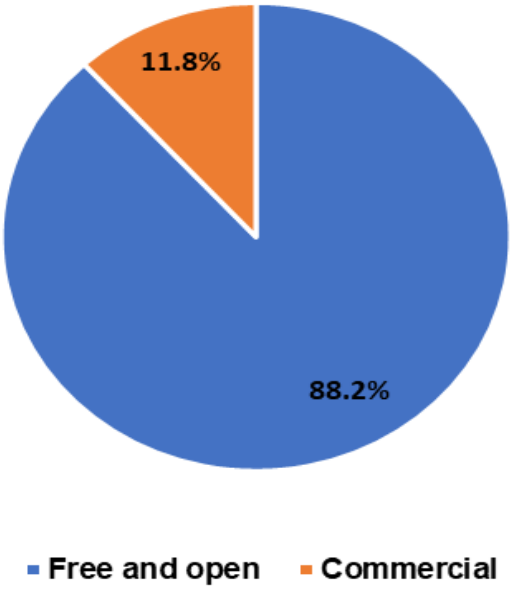
5. Cloud storage, the most cost-efficiency options for GIS users at the moment;

6. Cloud processing of Big Data, so already users do not need to manage their own servers or infrastructure;

7. Artificial Intelligence, that influence processes, image analysis, prediction, automation, etc.;

8. Virtual and Augmented Reality, that are dramatically adding a whole new dimension to GIS that people are used to.

Additionally, to evaluate the opinions of GIS users from Republic of Moldova, a questionnaire was distributed and after proceeding the answers some general ideas could be retrieved. Thus, the questionnaire “The current trend of using traditional GIS versus webGIS applications” was filled in by 101 respondents from different fields of activity or study, such as geodetic engineering and cadastre - 41.2%, geography - 27.5%, cartography and topography - 8%, also, in smaller numbers, there were representatives of the fields: urbanism and territorial planning, public services, spatial data infrastructure, land management, real estate evaluation and development, construction engineering and management, economics, tourism and hotel services, statistics, climatology. To the question: Do you have experience in using geographic information systems? 13.7% admitted they are advanced users, 33.3% intermediate users, 41.7% novice users, at the same time there were 5.9% of respondents who declared that they had only heard, even though the questionnaire was directed only to GIS users.




Figures 1. Answers to the question:
What type of GIS program do you use most frequently?

A dilemma in interpreting the results of the questionnaire was the differentiated answers to the questions: What type of GIS program do you use most frequently? where the answers were 88.2% - free and free, and 11.8% answered 11.8%, and at the same time to the question: What GIS program do you use most frequently? 41.2% answered that they use ArcGIS, 37.3% - QGIS, 9.8% - MapInfo and other software (figures 1 and 2). So, in the analysis of the answers regarding the purpose of using GIS, most of the respondents stated that they apply it in the analysis and visualization of spatial data – 56.9%. Among the main

challenges encountered are: accessibility and understanding, complexity of use, costs and accessibility, integration with other systems.

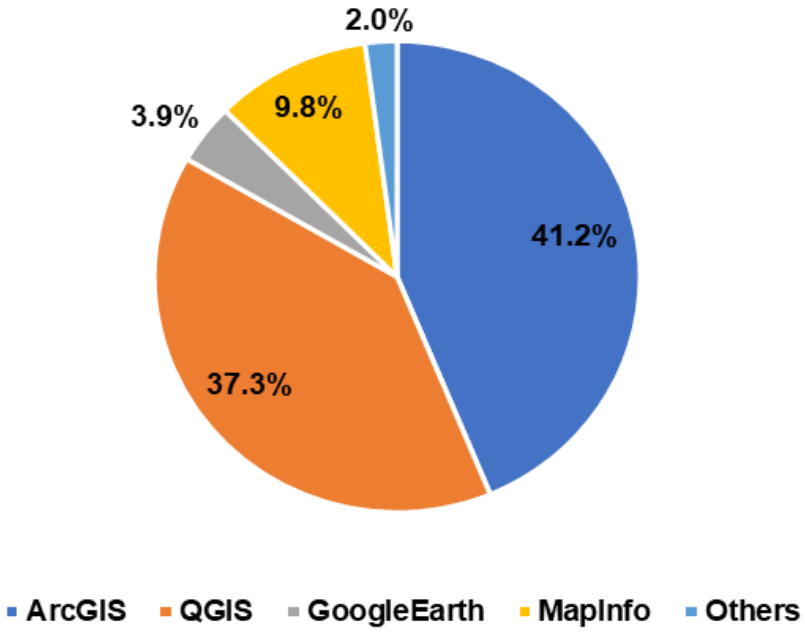



Figure 2. What GIS program do you use most frequently?

To the question regarding the influence of innovative technologies and GIS, 56.9% of the respondents answered that artificial intelligence will change the way GIS is developed and implemented. Also, according to the questionnaire, 94.1% of respondents agree that GIS will become an essential component in public administration and in the strategic decision-making process of the Republic of Moldova, and 5.9% - do not agree.

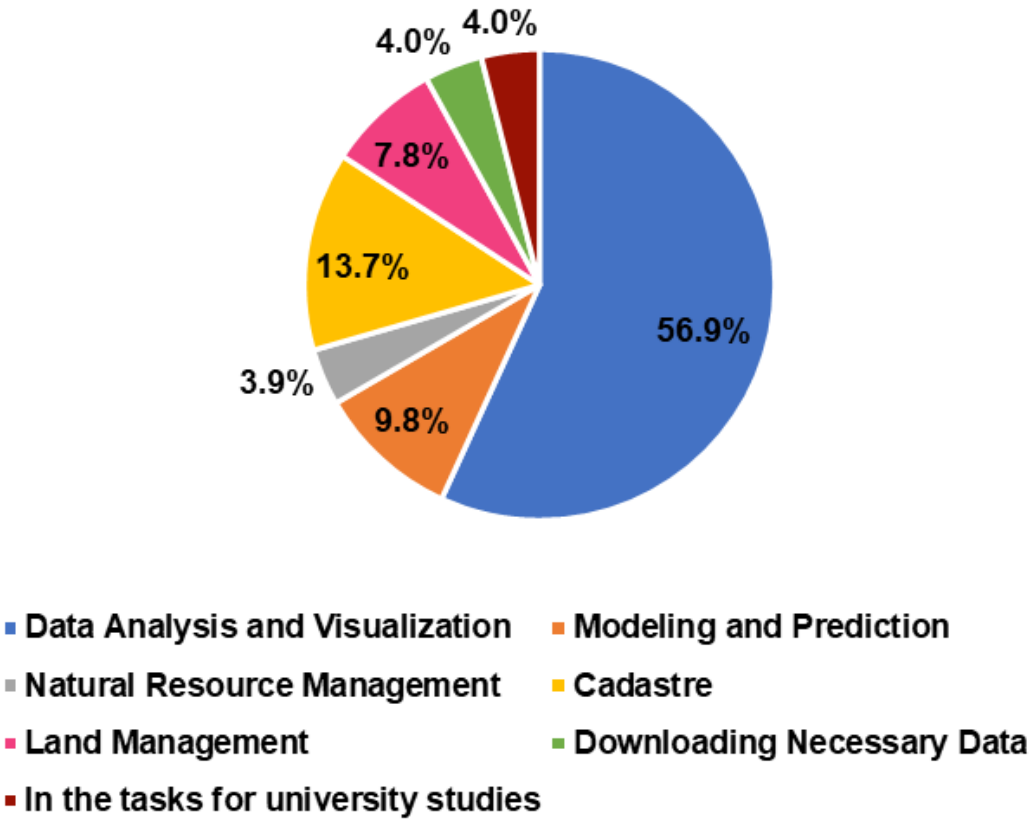


Figure 3. Answers to the question: For what purpose do you use GIS?

According to information presented in Figure 3, GIS users from Republic of Moldova use GIS mainly for: Data Analysis and Visualization is the dominant activity, taking up more than half (56.9%), Cadastre (13.7%), also Modelling and Prediction (9.8%) are the next significant areas. Land Management (7.8%), for Downloading Necessary Data (4%), tasks for courses at the University (4%) have relatively minor shares and Natural Resource Management has the smallest focus at 3.9%.

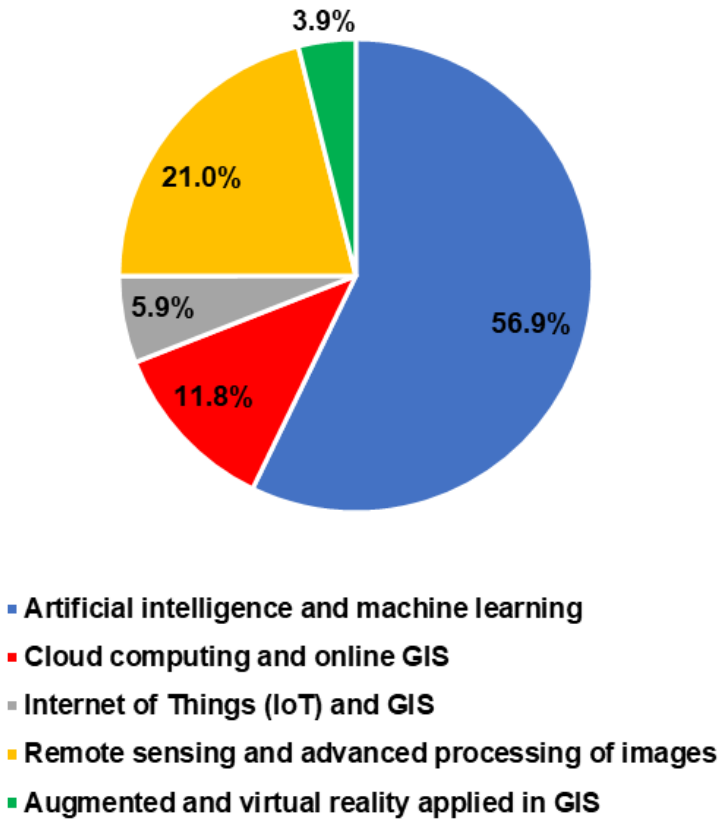



Figure 4. Answers to the question:
What technologies do you think will most influence the future of GIS?

Regarding the question about technologies that will most influence the future of GIS (figure 4), respondents believe that the most important innovations and changes will be led by artificial intelligence and machine learning: 56.9 %, also, advanced processing of satellite images: 21.6 %, cloud computing and online GIS: 11.8 %, IoT: 5.9 % and augmented and virtual reality: 3.9 % will most influence it.

At the same time, at the question: What improvements do you consider necessary for a more efficient implementation of GIS? a large part of the respondents considers that training and more accessible user education is very important: 41.2%, access to more open and updated data: 39.2%, better integration with other digital technologies: 13.7%, and of course lower costs for GIS solutions: 5.9 %. So as a conclusion very few respondents think that reducing costs is the main improvement needed.

The results of the questionnaire contribute to a deeper understanding of how GIS is integrated into professional and educational activities in the Republic of Moldova, as well as to identifying users' opinions on innovations in the field and their implication on the

development and implementation of GIS nowadays. The questionnaire also revealed that the terms "free" and "open" is not fully understood among GIS users in the Republic of Moldova.

The transition from traditional GIS to WebGIS and Cloud GIS represents a major transformation in how geospatial data is collected, analysed, distributed and used. Understanding current trends in the development and GIS implementation is essential for several strategic, technological and practical reasons: awareness of the need to adapt to technological evolution, implementation of GIS to improve the decision-making process, identification of GIS solutions in response to global challenges, deeper integration of the concept of interdisciplinarity in the process of GIS development and implementation.

## 4. Conclusions

Globalization of geographic information represents a complex irreversible process through which any spatial data become available and accessible worldwide, overcoming national borders and enabling international collaboration in various fields. Additionally, thanks to free and open spatial data and software, users have unlimited possibilities compared to last generation. Furthermore, taking into account the emerging trends it is sure that scientists and teachers must change the way in which they present geographic information and use GIS in order to reach as many geographic information users as possible. Furthermore, it is certain that these trends must be monitored and subsequently implemented in teaching and research activities in order to remain competitive in the era of technological boom and globalization.

Analysing the responses to the questionnaire designed for GIS users in the Republic of Moldova, it was found that time is still needed to understand and apply innovative solutions in the field. It was also determined that users still have a vague idea of the definition and meaning of the terms free and open data and software.

Current technological trends such as AI, VGI, and Cloud Computing are fundamentally transforming the way geographic data is collected, processed, and applied in decision-making processes. AI enhances data analysis through automation and predictive modelling, enabling faster and more accurate insights. VGI contributes to richer and more diverse datasets, often in real-time, improving the responsiveness and inclusivity of geographic systems. Meanwhile, Cloud Computing facilitates data storage, collaboration, and real-time access to GIS platforms. The integration of these technologies in decision-making processes significantly increases efficiency, accuracy, and adaptability. However, successful implementation requires not only technological upgrades but also improved user training, better data governance, and integration strategies.

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