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Review

Human-Centric Digitization in Montenegro: Progress through 17 Years of National Independence and Future Trends

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Abstract: Montenegro restored its national independence in 2006, and in the 17 years since then, the country has made significant progress in digital transformation, which is especially important for its accession to the European Union. In this paper, this period of 17 years of Montenegrin digital transformation is reviewed. The work aims to provide comprehensive coverage of the digitization processes across all relevant sectors, including healthcare, education, telecommunications and internet, personal and public transportation, tourism, agriculture, energy and sustainability, and public administration. The human-centric nature of digitization is emphasized where relevant, as well as related future trends. This paper also highlights barriers and limitations, such as the lack of consideration for cooperative intelligent transportation systems in national strategies, and user-related issues in digital public administration.

Keywords: digital technologies; digital transformation; digitization; development over time

1. Introduction

The country of Montenegro—which literally means "Black Mountain"—restored its independence on 3 June 2006, as a result of the independence referendum that was held on 21 May, earlier that year. More than 17 years have passed since then, and the country is preparing for its next historical milestone, as the accession of Montenegro to the European Union (EU) has been underway since 2012.

Many aspects of life have been transformed in Montenegro throughout those 17 years. One of the most powerful forces of transformation is digitization, which potentially affects every single service that is provided. With the aid of digital technologies, the quality of life (QoL) of Montenegrin citizens—as well as of those who either reside in Montenegro or visit the country (e.g., tourists)—has significantly increased. Many activities and

projects currently aid the digitization process, such as the ongoing DigNest project (Digital Entrepreneurial Nest and Industry 4.0 in Montenegro) [1] of the EU.

In one of our earlier works [2], we specifically investigated the state-of-the-art digitization efforts in the areas of healthcare, agriculture, and transportation—the latter was addressed from the technological perspective of cooperative intelligent transportation systems (C-ITSs). The work covered technologies (including related international standards), use cases, the relevant features and attributes of the country, and the associated considerations and implications.

In this paper, we comprehensively study the past 17 years of Montenegro in terms of human-centric digitization. This paper covers the areas of healthcare, education, telecommunications and internet, personal and public transportation, tourism, agriculture, energy and sustainability, and administration. This paper also focuses on the current status of the respective fields, as well as the future trends that are yet to come. This contribution aims to assess the progress of digitization within Montenegro from the EU perspective, with a particular focus on the human aspects of advancement.

Human-centric digitization is of paramount importance in the EU, as it aligns technological advancements with its citizens' fundamental rights and values. This approach ensures that digital transformation drives economic growth and innovation, and promotes inclusivity, privacy, and ethical standards. By prioritizing human-centric principles, the EU aims to create a digital environment that empowers individuals, enhances democratic processes, and safeguards personal data in every domain of digitization, from healthcare through agriculture to education or public transportation [3]. Such a digitization approach is particularly crucial in addressing the challenges of the digital divide, ensuring equitable access to technology, and increasing trust in digital services. Moreover, a human-centric strategy supports the EU's broader objectives of social cohesion and sustainable development—it is essential for promoting a resilient and fair digital society and for fostering economic growth and productivity [4]. Recognizing this, the EU has made digital transformation one of its key priorities. The Digital Decade initiative [5] outlines the EU's ambitious targets to steer this transformation through 2030. The EU's approach to digitization aims to create a digitally empowered society and economy. The EU's 'Digital Decade' targets four main areas: digital skills; secure and sustainable digital infrastructure; digital transformation of businesses; and digitization of public services. Through these efforts, the EU aspires to become a global leader in the digital realm, driving sustainable growth, enhancing public services, and improving the overall QoL for its citizens.

Montenegro has placed significant emphasis on digitization as a priority for its economic and social development, particularly in the context of its EU accession efforts. The country's focus on digital transformation is embedded within its broader strategy for innovation and smart specialization strategy (S3) [6]. The S3, adopted in 2019, highlights information and communication technology (ICT) as a key horizontal priority that supports various other sectors. The strategy aims to foster economic growth by leveraging digital technologies across multiple fields, such as energy, sustainable agriculture, advanced materials, sustainable tourism, and health services (i.e., smart specialization platform). Furthermore, the 2023 progress report of the European Commission (EC) on Montenegro [7] notes that the country has continued its efforts to advance digital and green transitions despite facing infrastructural challenges. The report emphasizes the need for Montenegro to strengthen its administrative and financial capacities to implement major public investments effectively, which include digital infrastructure projects. Montenegro is working on improving its e-government services to enhance public administration efficiency and transparency. This aligns with broader EU objectives to increase digital public services availability and quality, fostering a more integrated and competitive digital economy within the region. In summary, Montenegro's priority on digitization is reflected in its strategic documents and ongoing efforts to integrate digital technologies into various sectors, aiming to enhance its economic resilience and align with EU standards. On the other side, a deeper analysis of lessons learned from Montenegro could serve as a baseline for other local and

regional initiatives across Europe, which can be further used as a case study for testing scientific findings on isolated impacts.

The purpose of this contribution is to provide a comprehensive, detailed overview of the history, current state, and potential future of digitization efforts in Montenegro. This is particularly relevant for industrial partners, investors, regulators, divisions of research and development, the related scientific community as a whole, as well as high-level decision-makers. Regarding the scientific community, such regional reviews are rather beneficial, as they may highlight crucial dependencies, along with notable potentials and limitations. Beyond the comprehensive overview of the investigated fields, the authors collaborated with numerous Montenegrin institutions to enable insight into aspects that are otherwise unavailable publicly in the scientific literature at the time of writing this paper. For instance, in the case of education, aggregated data were collected from every single Montenegrin institution of higher education. Additionally, the authors must highlight that the contribution not only supports the upcoming digitization efforts within Montenegro but may also provide valuable information for other countries within the region (e.g., harmonization of development), EU member countries, as well as any country that is currently undergoing the process of digitization—particularly those within similar phases of development. In contrast to our previous work [2], this contribution focuses on the long-term evolution of the investigated areas and also approaches progress from a human-centric perspective. Moreover, each sector is studied in a more complete manner, e.g., in the case of transportation, all means are considered, and digitization in multimodal transportation is emphasized.

The remainder of this paper is structured as follows. Section 2 specifies the materials and methods employed in this work. The areas of healthcare, education, telecommunications, and internet, personal and public transportation, tourism, agriculture, energy and sustainability, and administration are discussed in Sections 3–10, respectively. The relevant future trends are addressed in Section 11. This paper is concluded in Section 12.

2. Materials and Methods

In this section, the materials and methods used by our research effort are briefly summarized. First, this work is partially based on the conventional analysis of the scientific literature. This was achieved via relying on specialized databases—such as IEEE, as the vast majority of related technologies are associated with electrical and electronics engineers—as well as general abstract and citation databases—such as Scopus. The latter was not only used to search for scientific publications on specific topics but also for performing numerical analyses (e.g., calculating the number of journal papers addressing a given technology).

We also studied statistical databases and legislative documents. For statistics, we primarily relied on the data published by the Statistical Office of Montenegro (MONSTAT). Additionally, we gathered information from other sources such as the World Health Organization (WHO), the World Bank, and the EC. Statistical information was also obtained from the Government of Montenegro, yet such a source was used more for legislative information, policies, and strategies. Moreover, reports published by Montenegrin ministries (e.g., Ministry for Information Society and Telecommunications, Ministry of Public Administration, etc.) were likewise incorporated into the presented analyses.

The authors of this work consulted with numerous officials—including lawmakers—to enhance the quality of the review and to ensure its factual accuracy. The institutions of the Montenegrin authors of this work (University of Donja Gorica, University of Montenegro, Chamber of Economy of Montenegro, and Clinical Centre of Montenegro) extensively aided the research efforts. Other Montenegrin institutions—such as the Mediterranean University of Montenegro and the Adriatic University (also known as University Adriatic Bar) in the context of higher education—also helped this work with relevant information.

The presented results were obtained by employing data classification and aggregation as well. For example, in the aforementioned context of higher education, data—already classified by using pre-defined categories—was provided by every institution of higher ed-

ucation in Montenegro, which constituted the input for the calculation of the proportionate weighted average.

Finally, the work gathered information from project documentation and published results. Such data can highlight the efficiency of past development efforts, and emphasize the directions of progress and national priorities.

3. Healthcare

The healthcare system in Montenegro is a mixture of the public and the private sector. Healthcare institutions in the public sector include primary-, secondary-, and tertiary-level institutions. The primary level consists of health centers (18 in total) where doctors for children (e.g., pediatricians), women (e.g., gynecologists), and adults (e.g., family doctors) work. Support centers (e.g., mental health, lung diseases, etc.) and other organizational units (e.g., home treatment services) are also an integral part of primary health centers. The secondary and tertiary levels of healthcare are provided in other health institutions, such as the Clinical Centre of Montenegro, two clinical-hospital centers, and five general and three special hospitals. The public health system of Montenegro also includes state pharmacies, the Institute for Public Health of Montenegro, the Institute for Blood Transfusion of Montenegro, and the Institute for Emergency Medical Assistance of Montenegro.

At the end of 2022, 942 institutions were registered in Montenegro, founded by either domestic or foreign natural or legal persons. The aforementioned institutions in the private sector are registered to provide various specialist and sub-specialist services, pharmaceutical activities, dental services, and more [8].

The Ministry of Health oversees and regulates healthcare services, which is particularly present in the periodical assessment of existing situations and the creation of strategic objectives, as well as monitoring their implementation. The most recent strategy [8]—covering the period 2023–2027—clearly shows that the biggest problems in the work at the primary level are the lack of staff (mainly doctors) and that doctors and nurses are overloaded with administrative tasks. As a result, in primary healthcare, the goal of 70% of the insured's health needs is not met; instead, they are referred to the secondary and tertiary levels. On the other hand, the implementation of healthcare workers at the primary level to detect the risk of non-communicable diseases and to implement preventive and screening programs has not been used at all [8].

The Ministry of Health also initiates and supports all initiatives and projects regarding the digitization of the public sector. The digitization of Montenegro's healthcare system was recognized as a priority at the end of the last millennium. The first information system was established in the Health Insurance Fund in 2000. To this day, the most significant number of health service providers are fully or partially included in the unique health information system [9].

Figure 1 illustrates the most essential phases in the development of a health information system at the national level in Montenegro since the process is still ongoing and new significant investments—in cooperation with the United Nations Development Program (UNDP) as well as by usage of national funds—are foreseen [8]. The main point of reference for the users of the health information system is the web portal named "e-Zdravlje". At the time of writing this paper, there are 11 electronic services for citizens and 2 services for institutions. According to the analysis of our earlier research [2], this is the most popular service used by the citizens of Montenegro, compared to all public services (37%, with the next most frequently used at 18.3% being e-services). This portal groups the essential features of the healthcare system, such as e-pharmacy (providing information on the supplies of medicine amongst pharmacies), e-prescription (allowing the paperless prescription of drugs), e-results (a fast and efficient way of sharing the results of biochemical and other analyses amongst authorized users), and e-appointments (a scheduling system that aims to avoid long queues at healthcare institutions). Implementing services and features like these not only prevented numerous unnecessary direct contacts—which was particularly important during the COVID-19 pandemic—but also significantly improved time man-

agement for patients and healthcare service providers. However, from the perspective of implemented integration and data and process workflow between different levels of the healthcare system at the national level in Montenegro, key elements are missing, as summarized in Table 1.

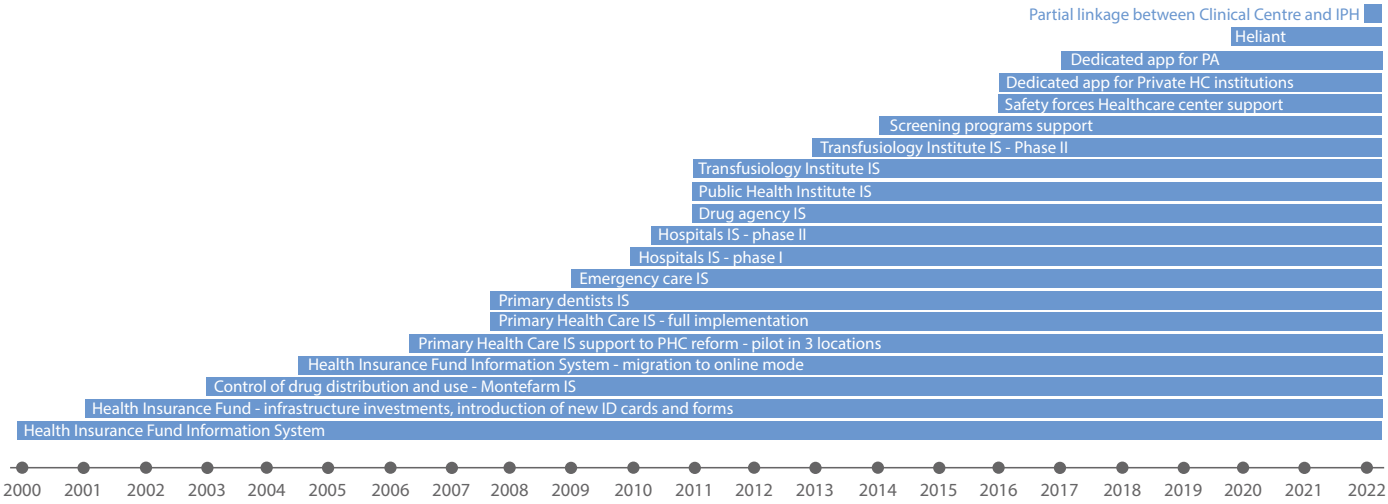

Figure 1. Phases in the development of the integral health information system in Montenegro.

Table 1. Full and partial integration of healthcare institutions into the Integral Health Information System of Montenegro.

Level of Healthcare	Fully Integrated	Partially Integrated
Primary level	Health centers; Institute for Emergency Medical Assistance of Montenegro	n/a
Secondary level	General and special hospitals	n/a
Tertiary level	n/a	Clinical Centre of Montenegro
Other levels	Pharmacies; Institute for Blood Transfusion of Montenegro; Institute for Public Health of Montenegro; Institute for Medicines and Medical Devices; Health Center of the Security Forces of Montenegro	n/a
Private sector	Private dental offices; pharmacies and healthcare institutions that are part of the health network	Other healthcare institutions
Authorities	Health Insurance Fund	Ministry of Health

The introduction of digital health solutions indeed brings about significant changes in healthcare delivery, requiring a shift in working processes and mindset among employees and managers alike [10]. Before considering any continuous professional growth through learning and skill enhancement, as well as adaptable work practices, the lack of medical and non-medical staff was evident throughout the years in Montenegro, as illustrated in Figure 2 [11]. In accordance with recent data from the World Bank, the index of the number of physicians (per 1000 people) for Montenegro is 2.8, while the highest European value is 7.1 (in Sweden). It is also important to highlight that age categories have changed over the years [11] as follows:

- Physicians with specializations were dominantly in ages 45–54 (46.76%) in 2008; residents dominantly in ages below 34 (73.29%) in 2008; compared to physicians with specializations dominantly in ages 35–44 (32.32%) and above 55 (34.35%) in 2021; and residents dominantly in ages below 34 (56.59%).
- Other medical staff were dominantly in ages 45–54 (38.79%) in 2008; while in 2021, they were mainly in ages below 34 (28.37%), with the least dominant age group of 45–54 (20.02%).

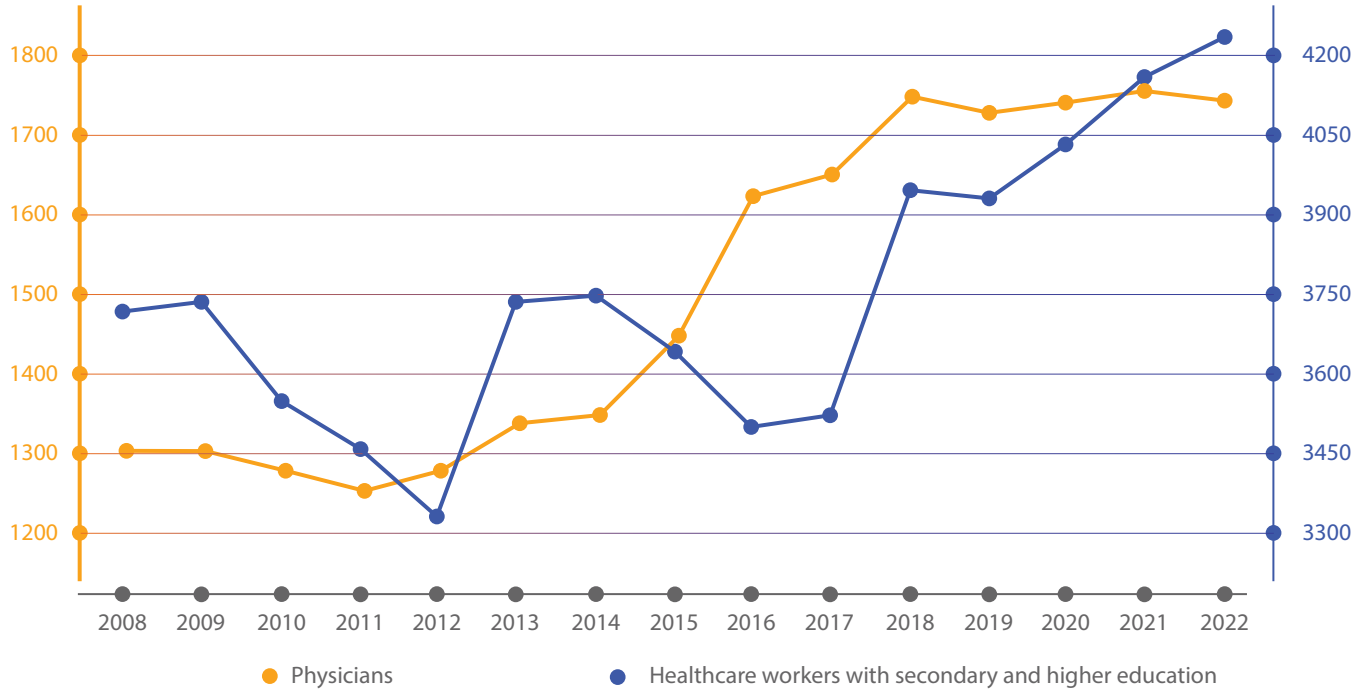

Figure 2. The number of healthcare workers employed in Montenegro.

The human-centric nature of the health information system became integrated during the initial steps that were made in 2000, and the digitization process was aimed at the optimization of the business process in healthcare, with direct benefits for healthcare providers and citizens as users of healthcare services. The following key advantages and challenges can be identified from the perspective of supporting the patients' well-being as core assets of the integral health information system [12]:

- Integration of patient data moving toward the creation of electronic health record (EHR). The patient's entire medical data and pertinent basic information are gathered in a single system, accumulated from birth, facilitating the establishment of a comprehensive electronic medical record. According to the report of the partner company in charge of the development of the system, the goal was to attain a degree of integration, wherein data are entered into the system just once, at its source, ensuring accessibility across the entire system as and when required. However, currently, EHRs are accessible only to physicians, while patients can access their own data only under special request to the insurance fund, which is still behind the general idea of having persons as owners of their own comprehensive lifelong repository of health-related data and documents [13].
- Support to centralized management and strategic planning of managers and authorities. All of the strategies adopted since the re-establishment of the independence of Montenegro were based on human-centric values such as equality, accessibility, solidarity, and reciprocity, placing the insured individual in the center of the health insurance system, aided by the legitimate and transparent management of the health insurance funds. However, integrated data are the cornerstones for effective resource planning,

regulatory documentation, quality assessment, certification and accreditation, billing, clinical research, and public health [14].

- Support for further system extensibility. Alongside such characteristics, the health information system is also highly integrated; once structured data are entered, it is available consistently and universally wherever requested by authorized users with access rights to the system. Additionally, shared resources are the foundation of the system, applications have unified solutions based on functional and organizational units, and reporting is centralized and automated.
- (Non-)Depicting private-public cooperation in the provision of health services. All the mentioned problems in the daily functioning of the health system are largely solved by the involvement of the private sector (942 institutions at the end of 2022) [8]. For health services where there is the greatest need (those that cannot be sufficiently provided by the public sector), the state signs cooperation agreements with private institutions. However, inadequate digital connectivity in the private sector complicates the monitoring of patients and the services provided. The consequences are numerous, including the fact that doctors cannot see medical reports about the services offered by private providers, and there is no unique or integral list of drugs issued to the patient.
- Perception of the usefulness of health information systems by medical staff. In the literature, many studies [15–17] have focused on assessing healthcare professionals' attitudes toward the usage of digital services and their usefulness. To the best of our knowledge, no similar study has been conducted in Montenegro. However, general feedback obtained in daily practice aligns with key factors of dissatisfaction among health providers, including the need to improve the efficiency of care processes, resource allocation, and billing procedures [14,18]. Moreover, there is a lack of support for collaboration and unintuitive user interfaces [16,17], which often detract physicians from time that could otherwise be devoted to direct patient care [19].

In summary, Montenegro's healthcare system has undergone a comprehensive and human-centric digital transformation. Governed by a mix of public and private sectors, overseen by the Ministry of Health, the system places a strong emphasis on equality, accessibility, and transparency. The establishment of the health insurance fund beneficiaries database served as a pivotal first step, setting the stage for further digitization efforts. The integration of structured data, centralized management, and the strategic planning of activities has enhanced the system's overall efficiency. The web portal "e-Zdravlje" is a user-friendly gateway to many electronic services, significantly contributing to improved healthcare accessibility and streamlined processes. Moreover, the system's adaptability was evident during the COVID-19 pandemic, when new digital services—including COVID-19 vaccination certificates—were swiftly introduced. Montenegro's healthcare system emerges as a commendable model, marrying human-centric values with cutting-edge digital solutions to provide efficient, accessible, and patient-focused healthcare.

4. Education

The COVID-19 crisis and the subsequent closure of educational institutions underscore the urgent need for digitizing the education system. This transformation not only enhances the system's resilience to future crises but also lays the foundation for a robust distance learning system applicable in both normal and emergency circumstances [20]. It additionally opens avenues for the digitization of various other processes within the education system.

The introduction of innovations into learning and teaching processes—driven by digital technologies—signifies the ongoing digitization of the educational system. This transformation is not a one-way street or a quickly achievable goal but represents a continuous journey toward a more technologically integrated and resilient education landscape.

The digitization of the education system goes beyond merely incorporating digital technologies into the teaching process [21]. It encompasses the comprehensive digital transformation of all processes within the education system. This includes the creation of

electronic services tailored for students, teachers, and parents, along with fostering data exchange with other institutions. The overarching goal is to modernize and enhance the efficiency of administrative processes across all departments.

Simultaneously, particular emphasis must be placed on addressing the needs of specific groups during the digitization of teaching and the improvement of education quality. These groups include children lacking access to technology (particularly those from economically disadvantaged backgrounds), children with special educational needs, and exceptionally talented students [22].

Considering the extensive scope and the imperative of digitizing the educational system, involving a multitude of institutions and interconnecting various activities, it is essential to formulate an education system digitization strategy. This strategic approach ensures a systematic and planned development in this realm, addressing the multifaceted aspects of digital transformation within the education sector [21].

The education system of Montenegro is intricate, encompassing institutions across various levels of education [23]. The distribution of these institutions is shown in Figure 3.

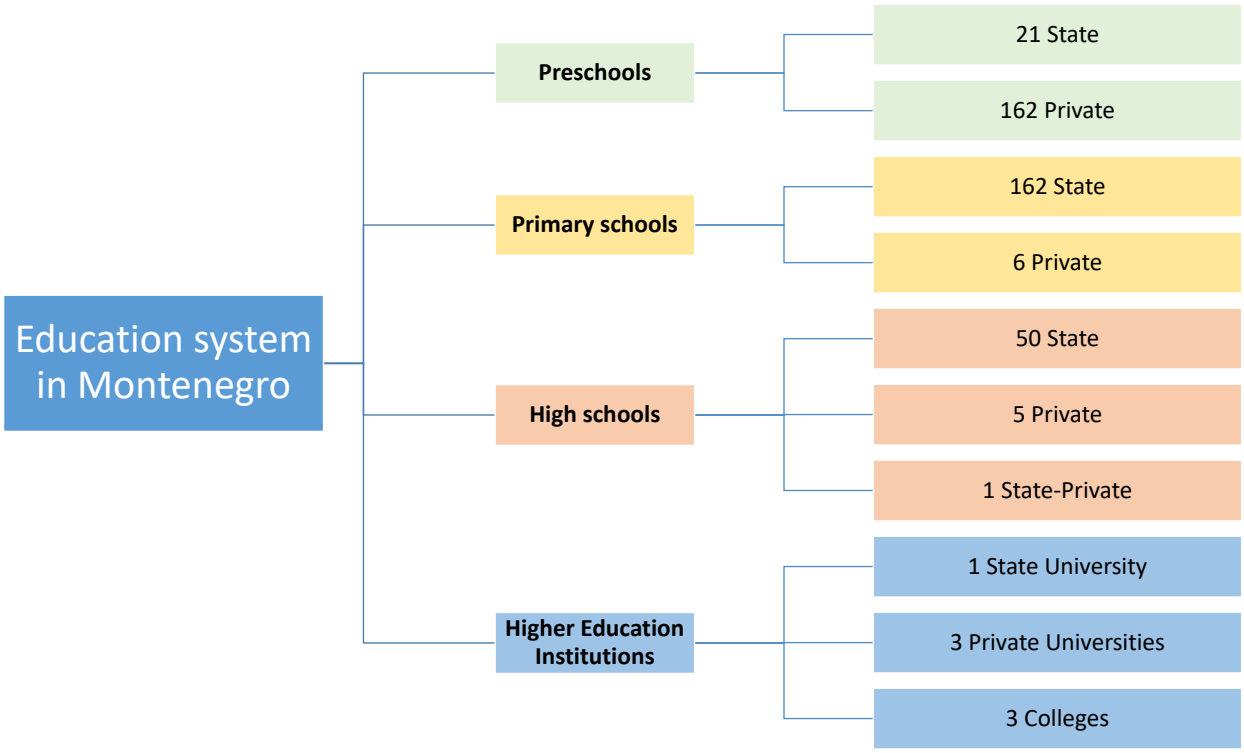

Figure 3. The distribution of education institutions in Montenegro.

The Ministry of Education, Science, and Innovation places its primary emphasis on organizing and managing the digitization transformation process in preschool, primary, and secondary education. In contrast, higher education institutions enjoy a considerable degree of autonomy in terms of business operations, organizational structures, and management processes. Consequently, our examination of the digital transformation process in education is divided into two categories. The first category pertains to preschool, primary, and secondary education, falling under the purview of the Ministry of Education, Science, and Innovation. The second category involves institutions of higher education, where universities and independent faculties are responsible for their own organization and management.

In the earlier stages, the digitization of education was guided by the Strategy for the Development of the Digital Society until 2020, encompassing two strategies. This initiative included a chapter on education primarily focused on infrastructure (e.g., internet connection, computer equipment), with limited emphasis on teacher education. The

intricate and diverse nature of the education system—coupled with experiences from the COVID-19 pandemic—underscored the necessity for a dedicated strategy. Consequently, the Government of Montenegro endorsed the Strategy for the Digitization of the Education System 2022–2027 in December 2021.

The overarching goal of this strategy is to systematically and purposefully implement the digitization process within the educational system. This endeavor directly contributes to enhancing the digital skills of both students and teachers, thereby elevating the quality of the teaching process and student education. Simultaneously, the strategy aims to digitize all facets of education, fostering a resilient educational system capable of addressing various societal challenges, including pandemics and weather disasters.

Aligned with several national and European documents—such as the Cyber Security Strategy, the Digital Transformation Strategy of Montenegro, and the EU Action Plan for Digital Education 2021–2027—the strategy underscores the need for planned digitization with predefined goals. It emphasizes the development of a corresponding digital ecosystem and the enhancement of digital skills across all education stakeholders. The scope of digitization extends beyond the teaching process to encompass administrative work and electronic services for students and parents.

The strategy delineates three strategic goals [23]:

- The enhancement of the Information System of Education;
- The development of a digital ecosystem to facilitate optimal conditions for the digitization process in schools; and
- The cultivation of digital skills among educational institution employees and students, fostering a sufficient level of knowledge to leverage technological benefits and enhance all processes, including teaching.

The implementation of the Strategy for Digitization of the Education System serves as the foundational basis for the successful integration of modern learning and teaching methods. It aspires to facilitate a holistic, efficient, and sustainable modernization of the educational system across all dimensions. In addition to digitizing the teaching process for improved educational quality, the strategy prioritizes an inclusive approach for special categories, including Roma children, those with special educational needs, and talented students [22]. Special attention is also directed toward improving the information system of education through the digitization of processes, interoperability, and the development of electronic services for all stakeholders.

The SELFIE survey has been conducted over four years to facilitate strategic planning in primary and secondary schools. This tool aids schools in incorporating digital technologies into teaching, learning, and student assessment. By collecting anonymous opinions from students, teachers, and school leaders, SELFIE helps identify areas of success and improvement, ultimately guiding priorities in the ongoing quest for educational advancement.

The journey toward digitizing education commenced in 2004, initiating a transformative era. A pivotal shift occurred with the integration of informatics as a regular subject, coinciding with the adoption of the Montenegrin Education Information System (MEIS) project. MEIS is composed of two essential components: (i) the enhancement of computer infrastructure and the introduction of internet connectivity in educational institutions, and (ii) the establishment of the Education Information System. This comprehensive system aims to collect data on all educational institutions, digitize education processes, develop electronic services, and establish interoperability.

From 2004 to 2010, there was a continuous effort to equip educational institutions with computer equipment. Approximately 6500 computers were procured during this period and distributed based on the schools' entry into the reform, aligning with the introduction of computer science subjects. After 2010, a significant slowdown in computer equipment procurement ensued due to financial constraints. Despite sporadic independent acquisitions by educational institutions, a systemic, large-scale procurement did not take place until 2023, when a EUR 6.3 million investment was initiated. This procurement is

expected to fulfill around 50% of the educational system's needs, considering the current age of the equipment in schools [23].

Simultaneously, efforts were made to establish internet connectivity, with ADSL introduced where technically feasible. In locations where ADSL was not viable, satellite internet was implemented in 61 locations, and mobile internet was implemented in 50 locations. Approximately 120 locations without internet access are slated to be covered by mobile internet. In facilities lacking internet connectivity, approximately 4% of students continue their studies.

The implementation of the Education Information System commenced in 2010, starting with the first schools. At the time of writing this paper, all educational levels—including preschools, primary and secondary schools, resource centers, music schools, and adult education organizers—both private and public, utilized the Education Information System. This system plays a pivotal role in data collection on children, employees, subjects, educational programs, and facilities. It serves as a tool for creating statistics and conducting analyses at all levels of education.

Users of the Education Information System include teachers and educational institution management (about 10,000 users), the Ministry of Education/affiliated institutions (about 300 users), other institutions monitoring various aspects of education (about 1000 users), parents (about 100,000 users), and the general public [23]. The system not only facilitates data collection but also digitizes various educational processes, ensuring efficient issuance of licenses, invoicing, enrollment, certificate issuance, schedule creation, exam applications, early identification of at-risk students, and monitoring of violence in educational institutions.

The assessment of the quality of the teaching process and learning in IT courses/modules at primary and secondary schools—specifically, those focusing on ICT—is conducted during supervision by the Bureau for Education Services and the Centre for Vocational Education. The observations from the Bureau for Education Services thus far highlight a relatively modest level of ICT knowledge among certain IT teachers. This underscores the necessity for continuous professional development, given the constant and rapid changes in this field.

From 2017 to the present, the Bureau for Education Services has organized 6 seminars, engaging 117 participants in programs such as digital pedagogy, application of ICT in mathematics teaching–trends, robotics, smartphones as a teaching tool, teaching mathematics with the use of information and communication technologies, animation and simulations in science teaching, and the development of critical thinking.

The professional development programs for teachers in the field of ICT have seen an increase in the number of accredited courses, as reflected in the Catalogues of Professional Development Programs offered by the Bureau for Education Services and the Centre for Vocational Education. However, there is a limited number of teachers who have undergone education in this domain in the last decade.

Over the past 10 years, the Ministry of Education, Science, Culture, and Sport (MESCS) has conducted various training courses. These courses are illustrated in Figure 4. These training courses—primarily financed through the Instrument for Pre-accession Assistance (IPA) funds or donations (from entities such as Microsoft, Oracle, and UNICEF)—have played a crucial role in enhancing the ICT competencies of teachers and education professionals. Furthermore, in the last 10 years, the Ministry of Education signed a contract with many worldwide-known companies offering their services to students and teachers, such as Microsoft 365, Oracle Academy, and Cisco Academy.

Currently, higher education institutions in Montenegro are undergoing an intensive process of digital transformation. Learning technologies and digital platforms are no longer an afterthought; they are critical for teaching and learning. The COVID-19 pandemic forced colleges, universities, instructors, and students to rapidly adopt digital services. Some institutions were prepared for the shift; those who were unprepared had to catch up quickly in this post-COVID period. The digitization of higher education is driven by and built on digital technologies. It changes the educational landscape significantly, helping higher

education institutions to operate most effectively, stay competitive in an increasingly digital world, and prepare learners for the digital workplace. To date, there are four universities in Montenegro: one state university, which is the largest (with 80% of students), and three private universities. As of 2023, universities are at different stages and scopes of the digitization process. All of them focus on digital learning in the higher education context, as well as enhancing learner and instructor experiences. However, it is important to note that no university has focused on creating new instructional models through policies, planning, partnerships, and support. The process of digitization of education at Montenegrin universities typically consists of ad hoc activities and is not adequately organized, despite the fact that universities use a large number of different digital services.

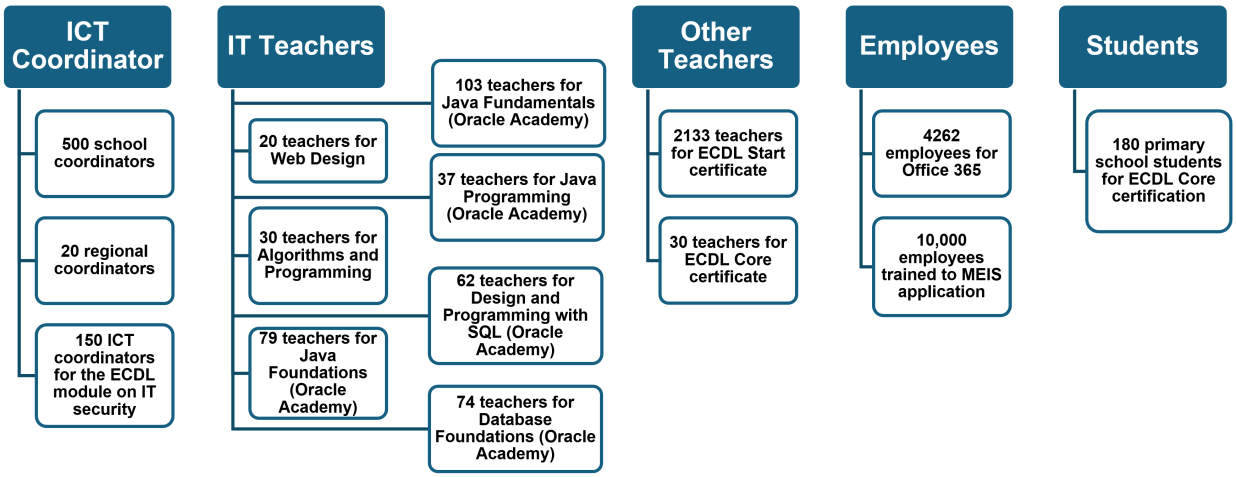

Figure 4. Human capacity building in Montenegrin digital education over the past 10 years [23].

The digital transformation of Montenegrin Higher Education Institutions (HEIs) is analyzed through seven aspects: (i) digital learning technologies; (ii) instructional modality; (iii) personnel and support services; (iv) organizational policies and planning; (v) instructor development; (vi) learner development; and (vii) partnerships [24]. Some universities in Montenegro might already be in the middle of a transformation, while others might just be starting.

1. Digital learning technologies. Digital learning technologies play a pivotal role in digital teaching and learning, as essential tools across various instructional modalities to actively engage learners [25]. Some commonly employed digital teaching and learning technologies include the following: (i) learning management systems (LMSs); (ii) synchronous technologies; (iii) multimedia applications; (iv) collaborative applications; (v) cloud-based technologies; and (vi) emerging technologies (artificial intelligence (AI), extended reality (XR), augmented reality (AR), virtual reality (VR), analytics, and other) [24].
2. instructional modality. With the increasing availability of online courses in many institutions and programs, students now enjoy a broader range of options [26]. They can choose to complete courses and programs at their convenience, from any location. The following is a list of common instructional modalities: (i) on-campus technology-enhanced; (ii) hybrid/blended; (iii) asynchronous online; (iv) synchronous online; (v) bichronous online; and (vi) HyFlex [24].
3. Personnel and support services. The growing prevalence of digital teaching and learning in various instructional modalities requires additional investments in support services and personnel at universities and colleges [22]. Support, services, incentives, and recognition motivate instructors to adopt innovative digital teaching methods. Some of the personnel and support services are (i) instructional designers; (ii) technology

support specialists; (iii) academic and student support services; and (iv) incentives and recognition [24].

4. Organizational policies and planning. Administrators need to be equipped to spearhead digital teaching and learning initiatives and provide support for overall teaching and learning across various subject areas [21]. Leaders should persist in incorporating research-based practices into their decision-making processes and recognize the value of digital teaching and learning innovations across all facets, including (i) policies and standards. Institutional policies and standards need to be set up for digital teaching and learning; (ii) strategic planning is "the process of defining a strategy as well as deciding on the resources that are allocated to pursue a strategy in order to achieve firms' goals"; (iii) funding models. Administrators should examine funding models for different modalities; (iv) equitable learning opportunities [20]. Institutions should ensure that students have the hardware, software, and internet access they need to participate in online courses; and (v) overall, more policies are needed to support digital teaching and learning.
5. Instructor development. Such programs are designed to enhance faculty members' pedagogical and technological skills, as well as their understanding of accessibility, intellectual property, and best practices in online teaching [27]. Investing time in reassessing and implementing pedagogical best practices such as (i) pedagogical and technological skills; (ii) faculty beliefs; (iii) accessibility and (iv) intellectual property rights and copyright, which significantly improve the quality of online courses [24].
6. Learner development. Digital learning offers students diverse opportunities to acquire knowledge through various modalities, preparing them for the future workforce, where digital knowledge and skills are increasingly essential [27]. Success in digital learning is facilitated by factors such as technology resources, effective time management and self-regulation, engagement, and help-seeking strategies, as well as community building. Key elements contributing to the success of digital learners include (i) computers and internet access; (ii) time management and self-regulation; (iii) instructional content and people; and (iv) help and community building [24].
7. Partnerships. Collaborations with colleges, universities, professional organizations, and external industries enhance digital teaching and learning initiatives by leveraging the expertise of professionals in the field [26]: (i) collaboration with other universities; (ii) collaboration with professional organizations; (iii) collaboration with industry; and (iv) partnerships with colleges and universities [24].

An analysis of the digital transformation in Montenegrin higher education is shown in Figure 5. To achieve the aggregated implementation scores, we collected data from the University of Donja Gorica, the University of Montenegro, the Mediterranean University of Montenegro, and the Adriatic University. Each university assessed each digital learning discipline via a score between 0 and 5, reflecting the percentage of implementation at the institution (0: 0%; 1: 1–20%; 2: 21–40%; 3: 41–60%; 4: 61–80%; 5: 81–100%). Data were sampled every 3 years from 2006, and the resulting implementation score is the weighted average (80%, 10%, 5%, and 5%, respectively), based on the distribution of the number of students in Montenegrin higher education.

Generally, the digital transformation of the education system in Montenegro has continually progressed at varying intensities. Montenegrin universities make significant strides within the Partnership, predominantly owing to the Erasmus+ program and other EU frameworks supporting the digitization efforts in HEIs. The growth of digital learning technologies remains steady, largely attributable to numerous projects funded by both the European Commission and the Ministry of Education of Montenegro. These initiatives facilitate the acquisition of ICT equipment, aiming to enhance the capacities of HEIs. During the analyzed period, learning development has shown a commendable level of progress, primarily due to the exceptional circumstances brought about by the COVID-19 pandemic. The necessity for HEIs to adapt led to the organization of online lectures through different learning models. There was a notably inadequate level of progress observed in two crucial

dimensions of digital transformation: organizational policies and planning, as well as instructor development. The digitization process faced significant setbacks due to a lack of strategic planning and the adoption of necessary policies and procedures at both national and institutional levels. Moreover, the unstable political environment—marked by frequent changes in government over the past four years—contributed to a dearth of sufficient government support for this transformative process.

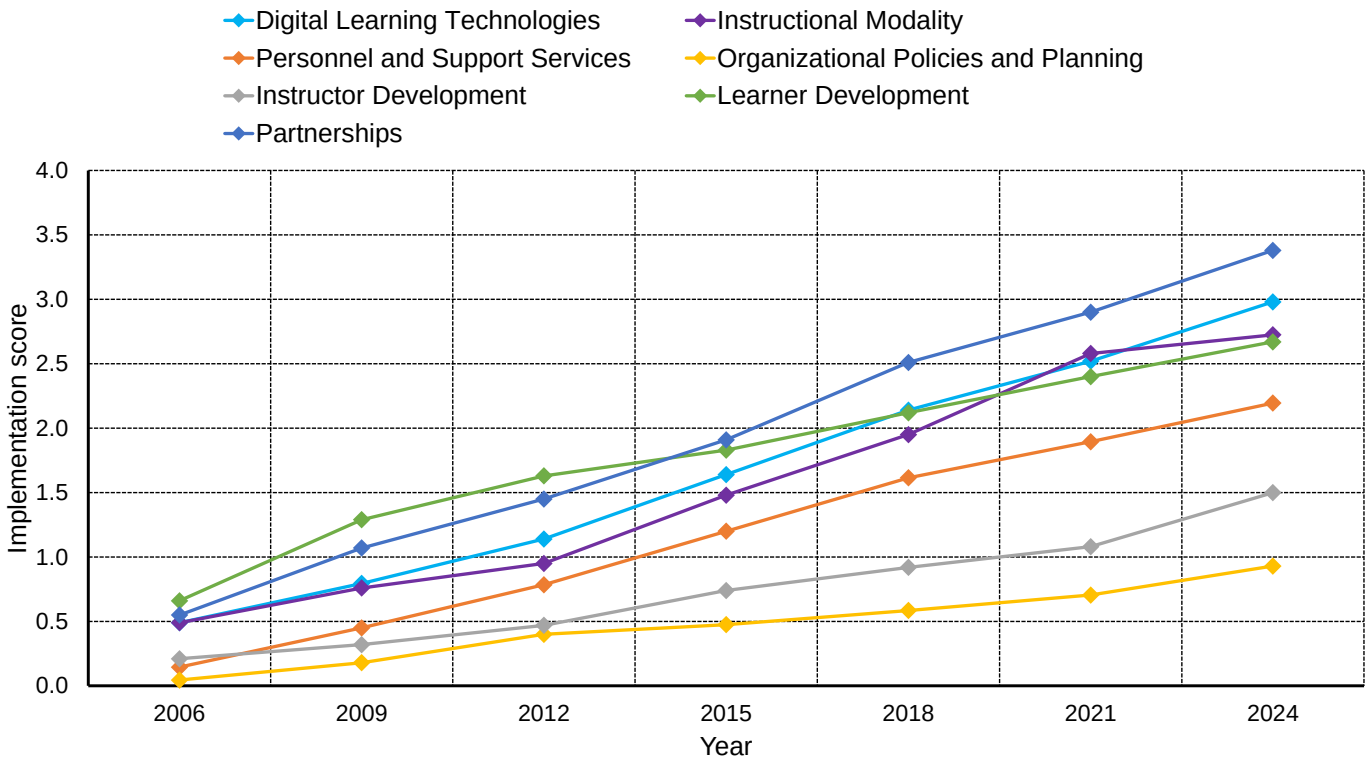

Figure 5. The digital transformation of Montenegrin HEIs.

A pivotal role in advancing the digitization of higher education was played, thanks to the Erasmus+ program, significantly contributing to the successful implementation of this transformative initiative. In the preceding Erasmus+ cycle (2014–2020), Montenegro was allowed to engage in 35 projects, comprising 8 coordinator projects and 27 partner projects, within the Capacity Building for Higher Education program. As the new Erasmus+ program cycle unfolded in 2021—and is set to extend until 2027—an additional 23 Capacity Building projects, consisting of 5 coordinator projects and 18 partner projects, were green-lit in the 2022 call. Many of these projects are strategically designed to lend support to the ongoing digitization efforts within the educational system. Furthermore, the Ministry of Science and Innovation played a crucial role by backing development and innovation projects at Montenegrin universities during the preceding period. This support was facilitated through a loan of EUR 15 million from the World Bank.

However, the Ministry of Education, Science, Culture, and Sport has supplied a minimal amount of computer equipment to all educational institutions up to, but excluding, the higher education level. The procurement of equipment for educational institutions did not occur uniformly in the same year but extended over a five-year period, contingent upon the timing of each institution's implementation of the educational system reform. The number of computers in each institution varies and is determined based on the school's student population. The age of the equipment ranges from 10 to 15 years, depending on the time when the institution is equipped. In recent years, schools have been acquiring additional equipment by using their own funds or through donations. The computer-to-student ratio in primary and secondary schools (1:15) is notably low.

Considering all the aspects mentioned in which we examined the digital transformation process of Montenegro's educational system, it can be deduced that there has been some progress in all areas. However, this progress is deemed insufficient, falling significantly below the European average. Unless there is a notable change, Montenegro, as a potential candidate for EU membership, will not attain the expected level of quality in its educational system within the scheduled time frame. In the upcoming period, it is imperative to concentrate on two critical facets of digital transformation: Organizational Policies and Planning, as well as Instructor Development. Successfully implementing these aspects will pave the way for a more efficient, balanced, and sustainable education system in Montenegro.

5. Telecommunications and Internet

After gaining independence in 2006, Montenegro went through significant changes in the sectors of telecommunications and internet technology. These sectors have played key roles in modernizing society, improving the economy, and strengthening connectivity with the world.

Since 2006, Montenegro has witnessed the rapid development of mobile telephony and the internet. Mobile networks have become ubiquitous, and the number of mobile phone users is constantly growing. This enabled citizens and business entities to communicate and access information more easily, both in the private and business sectors.

One of the important steps in the modernization of telecommunications in Montenegro was the privatization of state telecommunications companies. This opened the door for foreign investors to enter, and brought new technologies and expertise to the sector. In addition, market liberalization has contributed to increased competition, which is usually favorable for consumers in terms of the price and quality of services.

Montenegro, as part of the pre-accession negotiations for joining the EU, opened Chapter 10 (Information Society and Media) at the Intergovernmental Conference held on 31 March 2014 in Brussels. Within Chapter 10, the following areas are included: (i) electronic communications; (ii) information society services; and (iii) audiovisual policy—of which, electronic communications and information society services are covered by the Digital Transformation Strategy of Montenegro. Chapter 10 brings numerous advantages to the citizens of Montenegro, both for providers and users of services. The benefits of this chapter are reflected in wide access to the internet, aiming to provide everyone, regardless of physical distance, with fast access to the internet, encompassing electronic communications (mobile and fixed telephony), a large array of electronic services aimed at more efficient and faster procedures (such as company registration, appointment scheduling for inspections, electronic identification), protection of minors from inappropriate content with mandatory marking of programs suitable for various ages, and the promotion of national and European cultural heritage and the like.

Regarding the development of electronic communication networks and infrastructure, it is necessary to highlight the international agreements that Montenegro has signed. These agreements commit Montenegro to fulfill certain obligations within certain time limits. In that part, it is particularly important to emphasize (i) a memorandum of understanding on the 5G plan for the digital transformation of the Western Balkan region; (ii) a roadmap for reducing the prices of roaming services between the EU and the Western Balkans; and (iii) a regional agreement on roaming. Thanks to this regional roaming agreement, roaming was abolished in the countries of the Western Balkans starting from 1 July 2021.

Broadband development has also been key to the country's digital transformation. The increased availability of high-speed internet has contributed to the development of the digital economy, supporting online business, distance education, e-government, and other digital initiatives. Citizens of Montenegro now have access to numerous online services, from electronic bill payment to online shopping.

According to data from the Agency for Electronic Communications and Postal Services [28], internet infrastructure is experiencing continuous progress in the selection and

availability of internet access technologies, as well as in access speed. Figure 6 shows the progress of internet speed between 2015 and 2023 October.

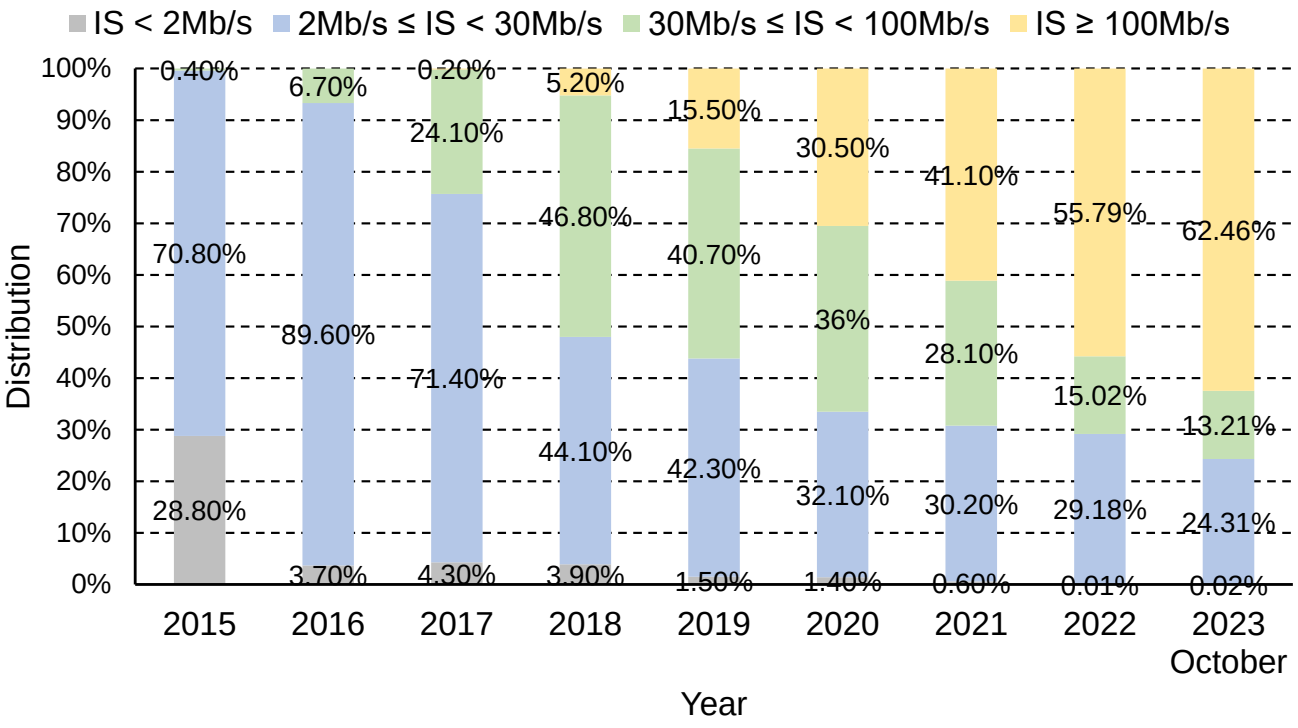

Figure 6. Internet speed in Montenegro between 2015 and 2023 October.

Data from February 2023 show that 77.93% of the territory of Montenegro is covered by the 4G/LTE signal, and in relation to the population, it is 97.47%. The availability of the 5G network is enabled on 10.35% of the territory of Montenegro, where 75.8% of the population lives. The number of 5G network users in February 2023 was 32,131.

The state has invested in infrastructure and technology to improve mobile phone and internet coverage, especially in rural areas. This contributed to a digital gap reduction between the urban and rural populations.

However, according to the Human Development Report for Montenegro 2020—*Reaching a Digital Future for All* [29]—digital access in Montenegro is unevenly distributed between urban and rural areas (80% vs. 63%, respectively), between the north and the south of the country (65% vs. 79%, respectively), and big differences can be seen in the use of the internet by young people and those over 65 (99.6% vs. 72.8%, respectively). It should be noted that according to MONSTAT data, on the level of use of ICT in households in Montenegro for 2023 [30], 81.3% of surveyed households stated that they have access to the internet at home. In the five-year period, there was an increase in the number of households that had access to the internet. In 2023, the percentage of households with internet access at home increased by 7 percentage points compared to 2019 (from 74.3% to 81.3%). The difference in internet usage between urban and rural areas decreased to 14%, from 85.9% in urban and 71.9% in rural areas. Based on the same survey, people who said they used the internet in the last 3 months mostly did it every day or almost every day. The number of people who used the internet in the last 3 months was 88.4%, of which 90.1% used the internet several times a day. The results show that with an increase in income, the percentage of households with internet also increases; 98% of users with an income of over EUR 600 used the internet, 88.2% with an income between EUR 300 and 600, and 46.2% with an income below EUR 300. When it comes to the territorial representation of the internet in households, it was the lowest in the north, amounting to 69.5%, while in the southern region, it was the highest, amounting to 88.5%.

According to the research on the degree of satisfaction among users of electronic communication services [31], users not only utilize these services extensively but also express a very high degree of satisfaction with their quality and prices across all market segments. The percentage of users satisfied with the quality of fixed telephony services is 86.3%, mobile services 85.8%, internet access services 87.9%, and AVM content services 86.1%.

In terms of legislation, Montenegro has been adopting regulations that support the development of telecommunications and the internet, including laws on electronic communications, data privacy, and cyber security. All these changes have a significant impact on the daily life of the citizens of Montenegro, from the method of communication to access to information and the possibility of performing various business activities. Telecommunications and the internet play key roles in shaping the future of Montenegro as a modern and connected society.

In 2023, 100% of surveyed companies had access to the internet, while 85.4% of companies had a presence on the web [32]. However, it should be noted that having a website—which is the case with most—is already a modern concept and requires additional interaction with clients, such as an online shop or a chatbot. Of the companies that have a website, 74.8% stated that they provide access to product catalogs and price lists, while 66.1% have links or references on their social network profiles. The results of the survey show that 22% of companies use a maximum speed of less than 30 Mbit/s for internet access; 28.9% stated that they use an internet connection speed of at least 30 Mbit/s but less than 100 Mbit/s; 27.7% reported using an internet speed of at least 100 Mbit/s but less than 500 Mbit/s; while 21.4% of companies use an internet speed of at least 500 Mb/s.

The percentage of respondents who have never bought or ordered goods or services via the internet is 51.6%, which represents a space for promoting e-commerce. According to the report of the Global Innovation Index for 2023 [33], Montenegro was positioned in 75th place out of 132 on the list of world economies. The scores for the ICT infrastructure indicator show a rank of 73/132.

6. Personal and Public Transportation

The significance of efficient transportation systems cannot be overstated, especially in a small and occasionally rural country like Montenegro, as they play a pivotal role in fostering economic growth, enhancing connectivity, and improving the overall quality of life for the nation's citizens. This chapter overviews the importance and significant characteristics of personal and public transportation in Montenegro, tracing the progress in digitization made during the 17 years of national independence.

Montenegro, spanning 13,812 km^2, exhibits significant geographical diversity. Despite its 293.5-km-long coastline along the Adriatic Sea, the country is predominantly mountainous. The native name, "Crna Gora" or "black mountain" originates from Mount Lovćen in the southwest. Montenegro's terrain is characterized by 50 peaks exceeding 2000 m. The highest peak, Zla Kolata at 2534 m, lies on the Montenegro-Albania border, historically competing with Bobotov Kuk at 2522 m in the Durmitor mountain range. Despite its extensive coastline and 17 islands, the average elevation remains high at 1086 m [34].

Montenegro grapples with the challenges posed by extreme topography, necessitating increased investments and maintenance expenses, especially in developing railway and road infrastructure. The subpar quality of the transportation infrastructure adversely affects economic growth due to the poor quality, high cost of transportation, and inadequate safety standards. Enhancing transport connections is critical to integrating Montenegro into regional trade flows, fostering political cooperation, and strengthening interpersonal ties by facilitating and enhancing the mobility of citizens and goods. However, they also significantly impact transportation safety, social development, and the environment. While a well-developed transport infrastructure stimulates economic growth, it also tends to introduce persistent and adverse effects, particularly concerning environmental, health considerations, and digital public administration [35], whether at the local, regional, or global level.

Given its coastal geography, navigating Montenegro by boat or ferry proves efficient and offers a picturesque mode of travel. The country boasts numerous harbors strategically positioned for optimal exploration, facilitating boat and ferry journeys along its coastline and beyond its borders. Yacht trips are available for those seeking a luxurious experience while gliding along Montenegro's shores, providing a wealth of onboard amenities and exceptional service. The standard car ferry route runs between Montenegro's exclusive ferry port in Bar and the port in the city of Bari, Italy, operating in both directions. As of the 2019 season, a new form of public transport is also available. Two cutting-edge hybrid trimarans will traverse Boka Bay, from Kotor through Perast and Tivat to Herceg Novi, solely powered by solar energy. This initiative aims to alleviate road traffic congestion, with the prospect of more eco ships anticipated [36].

Montenegro's network of paved roads spans 1729 km in total. This figure encompasses the recently opened 41 km segment of the Bar–Boljare motorway, inaugurated in July 2022, enhancing the motorway link between Podgorica and Belgrade. As of the current writing, this stands as the sole motorway section within the country. Within the paved road network, there are 12 main roads, classified as highways, and an additional 31 regional roads. In contrast, Montenegro also boasts 3548 km of unpaved roads [37]. Montenegro boasts a total of 20 towns, each with populations ranging from 136,473 in the capital, Podgorica, to 1073 in the smallest city, Andrijevica [38]. Podgorica showcases a coordinated system of traffic lights, and certain areas feature smart traffic lights capable of real-time adaptation to traffic conditions. Generally, the other towns are relatively small, often hosting only one or two traffic lights and roundabouts, with few exceptions. Cars and motorcycles dominate the country's roads, constituting nearly 88% of the vehicles in use. The remaining fraction includes less frequently utilized vehicles like buses, vans/minivans, and trucks. This infrastructure brings Montenegro's comprehensive bus network alive, interconnecting all its cities, with some routes extending to neighboring countries. Private minibus tours operate during the summer, offering an excellent opportunity for sightseeing as they cover all of Montenegro's landmarks. Utilizing taxis for transportation within Montenegro is also a common alternative, and many taxi services offer fixed rates for commonly traveled routes and destinations. Moreover, various providers offer car rental possibilities, but occasional rough rides may be encountered as only a third of Montenegro's roads are paved. To help road transportation, the construction of two European standard highways is underway, serving as vital links between Montenegro's cities and neighboring countries. An array of international standards has gained growing acceptance as fundamental minimum specifications for vehicle manufacture and assembly. The WHO actively advocates for the global adoption of these standards, which numerous countries now regard as essential requirements for all vehicles. Regrettably, Montenegro's regulations currently fall short, as they do not implement any of the eight essential vehicle standards [39]. Similarly, neighboring countries such as Bosnia and Herzegovina, Serbia, North Macedonia, and Albania face a comparable situation. In contrast, countries in the broader region, including Greece, Bulgaria, Romania, Hungary, Croatia, Slovenia, and Italy, have successfully implemented all eight standards. Despite this, the safety of road traffic in Montenegro is generally deemed satisfactory. As per the latest WHO statistics, Montenegro reports a total of 65 road-related deaths annually, translating to an average of 10.7 deaths per 100,000 inhabitants each year [39].

The railway infrastructure in Montenegro comprises single-track rails of standard width, encompassing three primary lines: (1) Vrbnica–Bar; (2) Podgorica–Tuzi state border; and (3) Podgorica–Nikšić. The cumulative length of these three lines, including station tracks, is 327.6 km, with 167.4 km electrified. There are 23 level crossings, where 19 are equipped with signal-safety solutions, including automatic barriers and light/sound signals, while 4 have horizontal/vertical road signalization without barriers [40]. The railway network density is 1.8 km per 100 km^2, revealing an unsatisfactory state in terms of both density and quality. This situation poses a perpetual risk of system-level vulnerability due to the convergence of road and rail traffic within the same corridor, navigating challenging

terrains. Operated by four main railway providers, Montenegro's railways converge at key stations such as Podgorica, Niksic, Tuzi, Bijelo Polje, and Bar. Presently, the sole railway connection to another country is with Serbia through the Vrbnica–Bar line, which implements a segment of the Belgrade–Bar railway traversing Montenegro. The temporal schedule exhibits a notable degree of reliability; nevertheless, the qualitative attributes of the trains manifest considerable heterogeneity. Certain trains evoke a reminiscent journey to the 1960s, while an alternative subset of trains unveils a surprisingly contemporary disposition, featuring amenities such as bicycle racks and spacious, contemporary carriages.

Since gaining independence in 2006, Montenegro has undergone remarkable transformations in its transportation sector, encompassing both personal and public modes of conveyance. While Montenegro has achieved significant advancements in legal alignments and practical implementations, further adjustments are still necessary. These include strengthening administrative and implementation capacities. Montenegro must also ensure additional harmonization and effective implementation of social, safety, and technical regulations for road transport. This involves meeting safety and security requirements in the maritime sector and adhering to safety and interoperability regulations in rail transport. Additionally, Montenegro needs to uphold standards for transporting hazardous goods by road. Regarding the digitization of personal and public transportation, a legal framework for intelligent transportation systems (ITSs) and an appropriate evolution path for cooperative ITSs must be established in close cooperation with the EU.

The Law on Roads enacted in 2020 has laid down the legal framework for the implementation of ITSs, a crucial prerequisite for aligning Montenegro's legislation with Directive 2010/40/EU on ITSs [41]. The equipment and functionalities within the Sozina tunnel adhere to the pertinent EU Directive concerning tunnels and roads. Operational control of the tunnel is centralized at the local control center located at Gluhi Do. As part of the continuous highway construction on the Smokovac–Matesevo section (Route 4), spanning a total length of 41 km, the installation of ITS equipment for traffic signalization, highway control, and management is planned [42].

For its railroad transportation, Montenegro has incorporated the Interoperability Directive of the EU into its legal framework. Nevertheless, the country currently lacks a specific strategy exclusively dedicated to the European Rail Traffic Management System (ERTMS) [42]. The Technical Specifications for Interoperability (TSIs) have been referenced in the Interoperability Directive, and their integration into national legislation is anticipated to occur gradually. Presently, ERTMS optical fiber has been deployed along the Bar–Podgorica–Bijelo Polje railway line. Additionally, the Podgorica railway station is slated to have ECTS level 1 equipment installed.

Regarding air transport, ITSs encompass innovative information, communication, and sensor technologies employed to consistently enhance traffic safety and service quality. Since achieving independence, Montenegro has become a participant in key international umbrella institutions and agreements that are crucial for the security and safety of air transport [42]. These institutions issue specific documents, such as annexes and publications, highlighting advancements in air traffic safety and security. Montenegro is obligated to incorporate these instruments into its regulatory framework to align with global and European criteria in this domain.

Montenegro has successfully incorporated Directive 2002/59/EC, establishing the EU's Vessel Traffic Monitoring and Information System (VTMIS), into its legislative framework [42]. The institutional oversight of the VTMIS system falls under the jurisdiction of the Ministry of Transport and Maritime Affairs. As for Directive 2010/65/EU on the Maritime Single Window system, certain elements have already been implemented through software, hardware, and training. Achieving full compliance with the directive requires investments to establish the Maritime Single Window information system. The initial phase of VTMIS implementation in Montenegro, supported by the EU, involved the installation of sensors at three locations along the Montenegrin coast. Data from these sensor sites are transmitted to the Control Centre, facilitating maritime information exchange with other systems both within Montenegro and

internationally (MARES, EMSA, etc.). The second phase includes the addition of closed-circuit television (CCTV) sensors at existing VTMIS sites, new sensor installations at Lake Skadar and Boka Bay, and the implementation of the "Single Window" information system (as per EU Directive 2010/65) [42]. Furthermore, with EU assistance, plans are in place to enhance VHF telecommunication coverage for vessel navigation on Skadar Lake and introduce AIS base stations to monitor the movement of passenger boats on the lake. Despite limited initiatives toward implementing ITSs in the transport sector, with VTMIS being a notable exception, only a few ITS sub-systems are currently operational on road networks. A promising example here is the published TSI for railways [43].

This poses considerable challenges to implementing C-ITSs in Montenegro. In the EU, the Platform for the Deployment of C-ITSs emerged in 2014 under the auspices of the EC services (DG MOVE). Its primary objective was to foster a shared vision among all stakeholders in the C-ITS value chain. Building upon the outcomes, the EC adopted the European Strategy on Cooperative Intelligent Transport Systems in 2016. Integral to this strategy is the C-Roads platform [44], a flagship initiative involving European Member States, road operators, and associated partners. This initiative focuses on testing and implementing C-ITS services with cross-border harmonization and interoperability as its main objectives. Since its official launch in 2016, C-Roads has demonstrated that C-ITSs are now integral in everyday road user experiences, with significant benefits poised for future exploitation. Through Europe-wide harmonization efforts and collaboration with strategic partners like the CAR 2 CAR Communication Consortium (C2C-CC), ASECAP, CEDR, EU EIP, and the EC, C-ITS deployments have covered 20,000 km of road sections equipped with mature ad hoc short-range communication units (ETSI ITS-G5) [44]. In proximity to Montenegro, C-Roads Core Member states such as Slovenia, Hungary, and Greece, along with Associated Member Croatia, have made significant strides in C-ITS implementation. Conversely, Montenegro is at a nascent stage in deploying ITSs. ITSs are part of the country's long-term goals, as outlined in the Transport Development Strategy until 2035 [42], and there are pilot projects for advanced ITS applications like fleet management for the transportation of goods in Podgorica [45]. Montenegro has undertaken significant strides toward digitizing its vessel registration process. Strategic initiatives in the realm of road traffic underscore the nation's commitment to implementing ITSs. This endeavor involves the integration of "new and developing information technologies—computers, sensors, communication systems, electronic devices, etc., with the aim of increasing the safety, efficiency, availability, and sustainability of the traffic network" [46]. As part of this initiative, electronic toll collection systems have been deployed on specific routes, including the Sozina tunnel and the Bar–Boljare highway's Smokovac–Mateševo section. Prioritizing the facilitation of cross-border electronic data exchange among relevant state authorities, clients, and ITS service providers is a cornerstone objective. Additionally, efforts are underway to establish a comprehensive system for monitoring and regulating public transport vehicles, alongside implementing a unified electronic ticketing system for public transportation services [47].

Although these measures collectively signify Montenegro's commitment to embracing technological advancements to enhance its transportation ecosystem, they are sporadic and without C-ITSs, which is not currently considered in the strategy for the next 13 years. It is crucial to underscore that C-ITSs play a pivotal role in shaping the future of transportation, particularly in terms of digitization. Digital technologies in personal and public transportation are fundamental for improving efficiency, safety, and overall effectiveness. As it navigates its strategic trajectory, Montenegro should not only consider the immediate ITS needs, such as traffic safety at intersections and railway crossings, but also prioritize the incorporation of C-ITSs to harness the broader benefits of digitization. The lack of experience, coordination structures, and information technology-related education in Montenegro's transport sector presents challenges that must be addressed to integrate ITSs successfully into its road and rail networks.

As the global landscape evolves toward digitized, smart, and interconnected transportation, Montenegro's recognition and inclusion of ITSs/C-ITSs in its strategies will be essential for fostering innovation, enhancing safety, and ensuring a seamless digital future in transportation.

7. Tourism

Tourism is one of the most important sectors of Montenegro. According to the Statistical Office of Montenegro [48], there were nearly 10 million overnight stays in 2021, roughly 95% of which was international tourism. While this number was merely 2.6 million in 2020 due to the COVID-19 pandemic, it was 14.5 million in 2019. Regarding international tourism, the most frequent countries of origin among the tourists were/are Serbia, Bosnia and Herzegovina, and the Russian Federation. The Central Bank of Montenegro reported that travel tourism amounted to a total of EUR 757.81 million in 2021 [49]. Note that the GDP of the country was EUR 4955 million in the same year [50].

The success of Montenegrin tourism is enabled by factors such as its favorable geographic position, its diverse natural resources, and rich cultural heritage [51]. The main points of interest include Bar, Budva, Herceg Novi, Kotor, Perast, Tivat, and Ulcinj—all of which are located on the coast of Montenegro. There are, of course, numerous places on the mainland as well that significantly contribute to tourism, such as Andrijevica, Cetinje, Kolasin, Mojkovac, Plav, and Žabljak—as well as Podgorica, the capital city of Montenegro.

Many forms of tourism are represented in Montenegro. Beyond beach tourism, the country also offers sports, nature, nautical, rural, cultural, health, wellness and spa, agricultural, gastronomic, and MICE (meetings, incentives, conferences/conventions, exhibitions/events) tourism [52–54]. The significance of beach tourism is well reflected by the location-based distribution of the annual overnight stays. In 2021, a total of 94.7% was in coastal towns, while only 2.1% and 2% were in the mountains and the capital city, respectively [55]. Moreover, the most popular destination was/is Budva, which is well known for its beach and is favored by both domestic and international tourists. Budva alone contributed 28.3% of all the annual overnight stays in 2021, albeit the Montenegrin beach season is concentrated in two months (July and August) [51].

Historically, since gaining its independence in 2006, tourism has always been one of the country's leading industries. Additionally, it needs to be highlighted that in 2007, Montenegro was considered to have the fastest-growing tourism industry worldwide [51]. The GDP of Montenegro in 2007 was EUR 2807.9 million overall, 3.3% of which was the share of tourism [56]. As a reminder, this share was over 15% in 2021. More than a million tourists arrived in 2007, resulting in well over 7 million overnight stays [57]. Mass tourism and real estate investing dominated Montenegro's tourism industry during its early years of independence. Therefore, it is not a surprise that most of the visitors were from neighboring Serbia as well as Bosnia and Herzegovina. Moreover, Russian citizens started acquiring real estate in Budva, which is rightfully referred to as the "metropolis of Montenegrin tourism" [57].

Employment in the tourism industry also increased significantly. In 2007, the employment growth rate was 27%, which means that about 15,400 people were employed in the tourism sector. The stagnation of tourism was evident in the year of the global financial crisis in 2009 when the growth rate of tourist arrivals was merely 1.69%. However, the same values in 2010 and 2011 were positive and continued on an upward trend until 2020—the first year of the COVID-19 pandemic [58].

The candidature for membership in the EU was an additional incentive for the country to turn to the Western market, so the number of guests from EU countries started increasing. The opening of the airlines made the country more accessible by air, and on the ground, it was made possible by the reconstruction of the main road, Cetinje–Budva, in 2018, and by the construction of the highway to the north, which was finished in 2022. An intensive advertising campaign in foreign markets, an extension of the season, the entry of world brands into the Montenegrin market, and a growing interest among foreign tourists in the

north have all contributed—and continue to contribute—to a positive trend in the tourism economy of Montenegro [59].

Tourism development results would not have been viable without specific strategies by the Government of Montenegro. The first Montenegro tourism development strategy adopted after gaining independence covered the period from 2008 to 2020. It was preceded by the human resource development strategy for the tourism sector and a spatial plan for the special needs of the coastal area [60]. The following tourism development strategy is focused on the current period between 2022 and 2025, followed by the country's digital transformation strategy (2022–2026), confirming the importance of tourism's digitization. The tourism development policy included the law on tourism and hospitality (2018) and several accompanying laws (law on tourist organizations; law on residence tax; law on ski resorts; law on mountain paths; rafting law) [60]. Smart specialization included tourism through the smart specialization strategy (2019–2024) and the operational program for implementing the smart specialization (2021–2024).

The law on tourism and hospitality—which was introduced in 2018 as mentioned above and is currently in effect—specifies the advertising and promotion of tourism, which covers the use of electronic media and digital platforms, as well as QR codes [61]. Additionally, the law addresses tourist agencies and enables them to conduct business (i.e., to offer their services to customers) exclusively online, as well as to keep a guest book that is online only.

The current law in Montenegro does not specify mandatory digital service requirements (e.g., free WiFi at hotels). It regulates the digital data exchange between state authorities, local administration, local bodies of the government, tourist organizations, providers of tourists, and hospitality services. However, nothing in relation to local digital services is regulated in general. Yet this only applies to the current law in effect and not to the supporting documents and handbooks.

It needs to be highlighted that the classification of touristic facilities in the rule book on types, minimum technical conditions, and categorization of hospitality establishments [62] does mandate specific requirements. First of all, according to the rule book, accommodation can be either a hotel (including the most expensive, luxurious hotels), small hotel (i.e., boutique hotel), hotel garni (i.e., hotel without its own restaurant), apartment (or apart) hotel, motel, guest house, or inn. For 3-, 4- and 5-star hotels, it is mandatory to provide WiFi coverage within the entire premise of the hotel—yet it is not specified whether access should be free or not—and for 1- and 2-star hotels, WiFi coverage is obligatory only for the reception area and the restaurant, but not for the rooms. In contrast, in the classification published in 2013 [63], the provision of WiFi was not among the requirements. For all hotel types, the (bed)rooms must be equipped with telephone service. For 5-star hotels, telephone end-user devices must also be included in the bathroom. Regarding television, at least one device must be provided in a designated television room, or one television per accommodation unit, regardless of hotel type. Cable television is mandatory for 3-, 4- and 5-star hotels. Additionally, 4- and 5-star hotels must provide separate televisions for bedrooms and living rooms. Regarding room temperature adjustment, the rule book specifies that the related equipment must have a digital interface, but this is only mandatory for 5-star hotels. As for entrance to accommodation, doors with an electronic opening system are obligatory for 4- and 5-star hotels, as well as for 4- and 5-star boutique hotels and 5-star apartments.

Moreover, there are also guidelines that support the provision of touristic services. For example, for any type of hospitality facility, devices that may be used for playing music are to be equipped with volume limitations (i.e., components that constrain the maximum sound volume of the device) [61].

The current version of the proposal for a new law on tourism [64] is at a state that may be subject to revision, and its estimated dates for parliamentary vote and national adoption are not known at the time of writing this paper. Based on what is available, the differences between the current law and the proposal mainly relate to presentation quality

(i.e., phrasing, structure, and clarity in general). However, there are certain differences in the level of relevant content as well. For example, the new law would expand the methods of contract modification (e.g., via email).

Regarding future strategies, while the digital transformation strategy for the following 3 years [65] does highlight tourism as a key sector, no tourism-related action is specified. The program of economic reforms between 2022 and 2024 [66] focuses on green tourism. In this context, green tourism refers to sustainability; essentially increasing the capacity of "green" (i.e., environmentally friendly) accommodation and diversifying the touristic product.

8. Agriculture

Digital agriculture (also known as smart farming) refers to the integration of modern technologies and data-driven solutions into various aspects of agricultural practices to improve efficiency, productivity, and sustainability. This involves leveraging technologies such as the Internet of Things (IoT), sensors, data analytics, machine learning, and automation in order to enhance decision-making and optimize agricultural processes. Six technologies are particularly interesting in the area of agriculture:

- The Internet of Things, because decisions need data collection through sensors and connected objects (e.g., smart hives);
- Cyber-physical systems, which consist of a set of primordial principles that allow defining the hierarchy of decision-makers and a decision cycle;
- Big data, as data are the most important things on which decisions are based;
- Cloud computing, which refers to the delivery of resources and services on demand over the internet (i.e., the access to data from different resources and high computing power via the internet); thus, it is an important computing step that facilitates the deployment of intelligent systems;
- AI, which is a powerful tool that can be used to help users in the process of making decisions;
- Autonomous systems, which involve advanced technologies and robotics to perform various tasks on farms without human intervention.

Montenegro's transition to digital agriculture presents an opportunity to modernize the agricultural sector, increase productivity, and contribute to rural development. By strategically integrating the technologies above, Montenegro can position itself as a leader in agricultural innovation while addressing local challenges and contributing to global food security.

The area of Montenegro [67] is 13,812 km^2, 2.6% of which is water, with a total GDP of USD 4.84 billion in 2019 (8% of the GDP comes from agriculture). EU accession negotiations with Montenegro were launched in June 2012, with agriculture and rural development opened in December 2016. Moreover, 38% of the total area is used for agricultural land which accounts for roughly 517,000 ha. Of those 517,000 ha, 13.7% (70,829 ha) are arable land. Throughout history, agriculture has played an important role in Montenegro, especially in rural areas, in order to reduce poverty. The average agricultural land per farm is 4.6 ha, accounting for all farms within the territory, 72% of all farms, and farm agricultural land with an area smaller than 2 ha. Over 60,000 households located in rural parts of the country derive some or all of their income from farming. With the starting preparations and transformation of various areas, the agricultural sector required transformation from a net importer to a high-quality yet low-cost export producer to gain access to international markets.

Montenegro is rich in diverse landscapes and climatic conditions. The climate ranges from continental and Mediterranean to mountainous, allowing various crops and vegetables to be planted. One major agricultural sector is beekeeping. In 2016, there were 2533 farms with 50,024 beehives (20 hives per farm). The average annual yield of honey was between 300 and 500 tons. Another sector is viticulture (wine and table grapes), which accounted for 0.87% of the GDP in 2016, being the most important export product of the food processing industry. Moreover, 4512 ha of vineyards produce an estimated 40 million

kilograms of grapes annually, with a wide variety of grape types (counting 496 different types). With its rich climate zones, Montenegro grows olives and citrus fruits near the coast to seasonal vegetables and tobacco in more centralized parts of the country [67]. Montenegro's farmers own 12,077 ha of orchards; 18,872 ha is used for vegetable crops, which produced 39,082 tons of fruits and 26,161 tons of vegetables in 2012. In addition to crop farming, livestock is another large sector in agriculture, with 32,675 holdings. The biggest part of livestock production comes from ruminants such as cows (6790 tons), sheep and goats (3030 tons). Pork and poultry account for 3170 tons and 3030 tons, respectively [68].

In 2006, the situation regarding farming land was similar to today's situation explained above. One major point of difference was that grassland and pastures were not used adequately. In the past, the country did not use its full farming potential, and rural markets and direct sales were the prominent factors of distribution. Commercial market production—with the exceptions of the wine and milk sectors—was just starting. With its application for admission to the EU, Montenegro has begun to adapt its agricultural processes and transform toward high-quality, low-cost exports.

With the help of the MIDAS (The Montenegro Institutional Development and Agriculture Strengthening Project) project, running from 2009 to 2019—and renewed for a second project called MIDAS2—the country started to transform and modernize agriculture in a manner consistent with the EU's pre-accession requirements.

MIDAS supported farmers in various fields and helped to achieve the following results [69]:

- The Ministry of Agriculture and Development integrated EU IPARD-compatible (the Instrument for Pre-accession Assistance for Rural Development programs (IPARD)) rural development measures into support programs to enhance the competitiveness of the sector;
- A total of 6337 people—including 1077 women—directly benefited from the project with improved agricultural services;
- A total of 1511 clients adopted an improved agricultural technology;
- A total of 278 agricultural households adopted agro-environmental measures;
- Critical food safety system elements were upgraded in EU-compliant manners;
- A total of 2142 ha of land adopted sustainable land management practices;
- A total of 98 applications were made to food establishment grants, with 68% completed successfully;
- A total of 658 commercially oriented ago-holdings were established;
- Agricultural census was implemented with its results disseminated;
- The Bar Border Inspection Post with veterinary and phytosanitary controls was established;
- An integrated farm register was built, which registers farms electronically;
- Procedures for the classification of food establishments and annual control plans were completed according to EU standards;
- The Veterinary Diagnostic Laboratory in Podgorica was accredited in 16 ISO 17025 [70] analysis methods;
- A total of 6678 client days of training was provided, including for 11,014 women;
- A total of 98.3% of targeted beneficiaries were satisfied with the timeliness and transparency of payout of EU-compatible direct payment;
- A total of EUR 6,502,733.10 in grant funds was disbursed, and EUR 7,700,000 in IPARD-like grant funding was awarded.

Those results led, first of all, to the modernization of agricultural holdings and brought digitization to processes through the use of more modern machines, which started to collect more precise data and were capable of data transmission.

Montenegrin agriculture remains largely dependent on manual farming, with technical and technological solutions being poorly explored, while at the same time, it has a strong ICT sector. The Viral project [71] aims to bring agricultural education and training to both formal and informal settings. ICTs can help the agriculture sector regarding reg-

ulatory policies, agricultural extension advisory services, market access, food safety, and disaster management.

Another project working closely with the Viral project is the DIPOL project [72]. Within this project, several workshops were held to help with digitization in agriculture. The workshops and solutions ranged from smart packaging to IoT-based water management, a food hub center of excellence, and blockchain and food supply.

The Food and Agricultural Organisation of the United Nations (FAO) and the European Bank for Reconstruction and Development (EBRD) [73] started a joint venture to support backward linkages between smaller-scale producers and the hospitality sector in the Western Balkans region, including Montenegro. This allowed seljak.me—a marketplace of the agrifood sector—to modernize their online presence with regards to currently available best practices. The central platform was scaled and included an online marketplace. In addition, the platform includes a knowledge-sharing service that is accessible to all agricultural producers.

With the progressive modernization of agriculture, digitization is becoming an increasingly important factor. One technology that is interesting to Montenegro is precision agriculture. With the help of GPS, sensors, IoT, ICT or robotics, plants, and livestock receive precisely the treatment they need. This impacts not only the decision-making process but can also help at farm-level optimizing processes. The resulting precision allows the best approach to be determined—not only for a complete field but also for individual plots. This is achieved by using sensors to collect data directly from the plant or soil. Decision models determine the state of the crop/soil and if there are any deficiencies and determine the best treatment [74].

Precision farming also includes crop management by observing the soil and all patches of a field; moreover, algorithms can determine the best land to plant which crop. This allows us to plan better and switch crop planting always to have the crops on the best possible land. For example, soilless farming using nutritious water can be essential when providing food to a growing population. As shown in [75] IoT devices monitor the pH level, temperature, water flow, and other essential factors to optimize crop yield.

Using data from various sources can help to increase productivity and make crops resilient against possible environmental factors. Employing satellite imagery, AI, and machine learning enables the identification and assessment of crucial indicators for informed decision-making in agriculture [76]. All the collected data are used to generate ready-to-use insights, helping decision-makers or even making the decision themselves.

AI has great potential to predict weather patterns for better activity planning and catastrophe protection. Autonomous farming vehicles can help with precision farming and apply pesticides and fertilizer. This helps to reduce the associated costs and environmental pollution, as well as saves water by planning better water irrigation systems, and through detailed weather forecasts, saving water when rain is in sight [77].

To be able to process all this information and also to be able to plan properly, software is needed. A notable example of such is 365FarmNet [78]. There are several versions available at different prices, including a free version. Such software helps to collect and provide information about the arable land index, general stock management, farm-specific basic weather, graphic farm maps, interactive annual calendars, and many more. The software is also a helper for precision farming by providing satellite data for sowing and fertilization, soil sampling, and lane planning.

The scientific literature on "smart agriculture" has grown significantly in recent years, with numerous publications exploring various areas and solutions. A Scopus analysis revealed 3205 publications on "smart agriculture" in the past two years alone. Europe was mentioned in 23 of these publications, while there were no results for Montenegro. Combining "smart agriculture" with "blockchain" yielded 169 publications for the same period. Surveillance in smart agriculture had 54 publications, energy-efficient IoT systems had 38, and contamination detection had 22. Crop monitoring and health management garnered 72 publications. The importance of deep learning systems in smart agriculture is

underscored by 448 publications under the search terms "smart agriculture" and "deep learning". Adding "automation" to the search terms resulted in 43 documents. Risk management in agriculture produced 202 results, and risk management for disaster prevention had 16 publications.

Future trends such as carbon farming in Europe were discussed in 5 documents and 110 globally. Another important trend, biodiversity in Europe, was covered in 2066 publications. Data-driven farming in Europe has 6 publications and 313 globally. Drought resistance was the subject of 11 studies mentioning Europe and 812 globally. Water management for farming in Europe was mentioned in 4 publications and 662 globally. Publications about indoor farms specifically mentioning Europe included 1 publication and 54 globally.

Europe's milder climate may contribute to its lower prominence in smart agriculture developments, which often target regions with extreme weather, such as Southeast Asia. However, with climate change, areas like crop management and risk management will become increasingly important, even in Europe. The number of publications on smart agriculture was strong in 2023, with 1469 publications. The year 2024 already has 562 publications at the time of writing this paper. From 2022 to 2023, the number of publications nearly doubled for all search terms.

9. Energy and Sustainability

A reliable power supply is a fundamental prerequisite for the economic and industrial development of modern society. The importance of an independent and competent electricity sector has been particularly evident in the last two years when Europe faced record electricity prices due to geopolitical events. The main priorities of the Montenegrin energy policy include the following [79]:

- Reliable, high-quality, and diverse power supply;
- Development of a liberalized, competitive, and open electricity market; and
- Sustainable energy development with environmental protection, increased energy efficiency, and increased use of renewable energy sources.

This section provides an overview of the electricity sector in Montenegro and considers its role in its socio-economic development.

According to the energy balance for 2022, power plants with a total installed capacity of 1049.71 MW contribute to the coverage of electricity consumption in Montenegro [80]. Let us first review the main generation capacities of the country by technologies.

With a share of 704.14 MW (67.08%), hydropower plants occupy a central place in the Montenegrin generation mix. The Piva hydropower plant accounts for the largest share of the total installed capacity of hydropower plants. The Piva hydropower plant has been in operation since 1976, and due to its rapid start-up capability, it plays a role primarily in power generation to cover peak loads. The total installed capacity of the Piva hydropower plant is 342 MW; in 1978, it achieved a record production of 1286 GWh. In addition to the Piva hydropower plant, the Peručica hydropower plant is also essential to the power system of Montenegro, and it is the oldest large power plant in the country, built as early as 1960. The Peručica hydropower plant is a run-of-river and storage power plant that uses water from the Zeta river basin, as well as the Krupac and Slano reservoirs. The total installed capacity of the seven generation units of the Peručica hydropower plant is 307 MW, with a record production of 1435 GWh in 2010. In addition to the large hydropower plants, Montenegro also has a significant number of small hydropower plants, the largest of which are Vrbnica (6.75 MW), Bistrica (5.6 MW), Jara (4.568 MW), and Glava Zete (4.48 MW). In addition to the existing hydropower plants, several projects are currently underway in Montenegro for the use of water from small and large rivers. First and foremost, the Montenegrin Electric Power Company is currently in the process of preparing technical documentation for the Komarnica hydropower plant, with a planned installed capacity of 171.9 MW and a potential annual generation of 213 GWh. As the Komarnica hydropower plant will have rapid start-up capability, it will play an important role in balancing the Montenegrin power system. The energy development strategy of

the country also envisages the use of the hydropower potential of the Morača River [81]. Unfortunately, the construction of hydropower plants on the Morača River has met with strong public opposition due to threats to biodiversity, the Morača Monastery, and the Đurđevina landslide. Hence, the future of this project is somewhat uncertain. In addition to the large hydropower plants, the small Otilovići hydropower plant with an installed capacity of 3.1 MW is expected to be commissioned during the second half of 2024.

Of the fossil fuel-based production capacities, only the Pljevlja thermal power plant—commissioned in 1982—is currently operational in Montenegro. The installed capacity of the Pljevlja thermal power plant is 225 MW, which is 21.43% of the total installed power plant capacity in the entire country. Although its share in the total electricity generation in Montenegro is up to 50%, the achievement of the net zero greenhouse gas emission targets of the EU will require the permanent shutdown of the Pljevlja thermal power plant. Several unrealized projects are related to the existence of the Pljevlja thermal power plant, from the construction of a second unit to the district heating supply of Pljevlja. Another current issue is the legal proceedings initiated by the energy community against Montenegro, as the Pljevlja thermal power plant exceeded the number of operating hours specified in the Large Combustion Plant Directive [82].

Two wind farms are currently in operation in the Montenegrin power system: Krnovo and Možura. The Krnovo wind farm is the first large wind farm in Montenegro, which was commissioned in 2017. It consists of 26 wind turbines with a total installed capacity of 72 MW. On the other hand, the Možura wind farm was commissioned in 2019, and it consists of 23 wind turbines with a total installed capacity of 46 MW. Thus, the share of wind farms in the total installed capacity of power plants in Montenegro is 11.24%. Despite the relatively low capacity factor of wind farms compared to conventional power plants, the share of wind farms in the total electricity mix in Montenegro was 8.7% in 2021. Even though Montenegro largely relies on the Pljevlja thermal power plant to supply consumers, after the commissioning of the Krnovo wind farm in 2018, Montenegro achieved a 38.8% share of renewable energy in final consumption [83]. This exceeded the target of 33% from the National Action Plan for the Use of Energy from Renewable Sources [84].

In the field of solar energy utilization, no central power plant has been built in Montenegro thus far. However, considering the transmission and distribution network development plans, it is expected that in the next few years, numerous solar power plants with an installed capacity of 5 to 15 MWp will be completed. In addition to these, three large solar power plant projects are in the planning stages: Montečevo (450 MWp), Briska Gora (250 MWp), and Velje Brdo (50 MWp). It is important to note that due to the high demand for solar power plant equipment, especially solar modules and substations, the realization period for these power plants will be slightly longer than planned. In addition to commercial power plants, it should be emphasized that the construction of smaller solar power plants on the roofs of residential and commercial buildings has increased significantly in Montenegro, mainly due to the numerous financial support programs. Nevertheless, the share of solar power plants in the total installed capacity of power plants in Montenegro is only 0.24%.

Energy balances contain annual data on production, stocks, imports, exports, conversion, and the distribution of all relevant energy sources. Energy balances thus provide a starting point for analyzing the current situation and making forecasts for the future development of the energy sector. Figure 7 shows the electricity balances of Montenegro for the period from 2017 to 2021. As can be observed, due to the dominance of hydropower plants in the generation mix, the generation capacity largely depends on hydrology. Thus, in 2017, Montenegro achieved a production deficit of 1121 GWh, while in 2018, there was a surplus of 274 GWh. In hydrologically unfavorable years, such as 2017, the generation deficit amounted to more than 30% of gross electricity demand. With record prices achieved on European power exchanges in 2022, the financial impact of power imports is incomparably higher than before. For this reason, activities to build new production capacity must be intensified in order to minimize the dependence on imports and to ensure the

security of supply. Due to the suspension of primary production processes at the aluminum production plant in Podgorica, the total electricity demand in Montenegro is expected to decrease by 15% in 2022. If the construction of new generation capacities proceeds at the planned pace, Montenegro is expected to become a net exporter of electricity, assuming average hydrology.

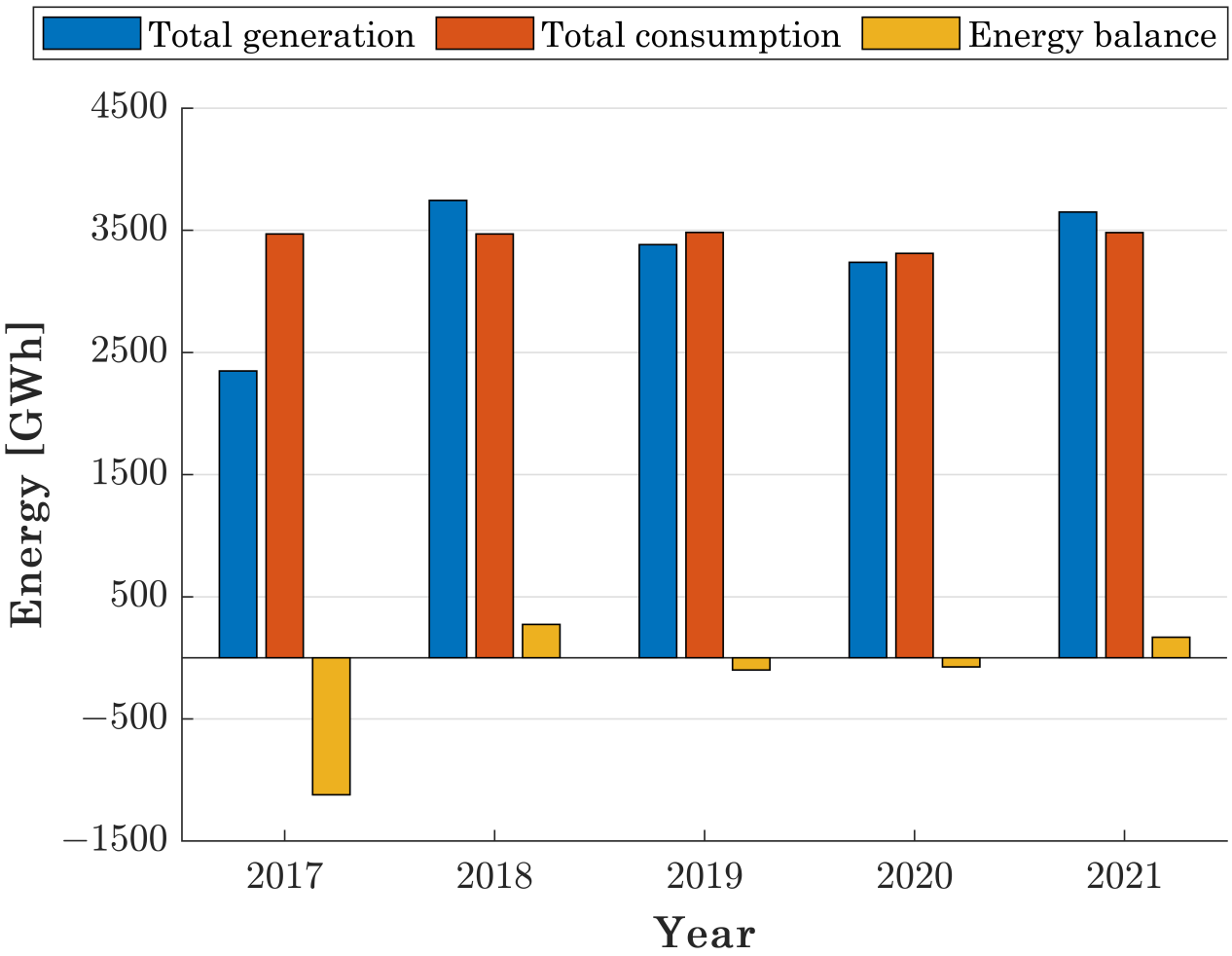

Figure 7. Montenegrin energy balance from 2017 to 2021.

Montenegro has embarked on a transformative journey in its energy sector. The country's energy mix—previously heavily dependent on fossil fuels—is undergoing a strategic shift toward sustainable and renewable energy sources. While the hydrological dependence of the energy sector is a challenge in years of unfavorable hydrology, investments in wind and solar energy offer a glimmer of hope. With steadily increasing contributions from wind energy since the commissioning of the Krnovo and Možura wind farms and an impressive pipeline of solar projects such as Montečevo, Briska Gora, and Velje Brdo, Montenegro is positioning itself at the forefront of green energy in the Balkan region. Despite the initial slow uptake of solar energy, there is significant momentum, particularly in residential and commercial installations. This distributed generation promises not only energy self-sufficiency for consumers but also diversification of the national energy mix. The energy balance charts in recent years highlight the country's dependence on imports, especially in years of low hydropower production. However, with the planned expansion of renewable energy capacity and the expected decrease in consumption due to changes in the industrial landscape, Montenegro is on the path to a more independent and sustainable energy future. By 2025, under average hydrological conditions, Montenegro might not only achieve energy self-sufficiency but it could also emerge as a net exporter of electricity.

10. Administration

The restoration of independence in 2006 presented Montenegro with both opportunities and challenges, particularly in the realm of public administration. Complex and robust bureaucratic systems were to be re-established, procedures and legislation readopted and appropriated, and services previously conducted on the federal level installed within the independent country. As challenging as these processes were, the circumstances offered an opportunity to update policies based on the possibilities provided by digitization. Additionally, as the Euro-Atlantic integration represented the central thread of public policies since 2006, digitization was vastly endorsed as an enabler of better public administration.

Proposals of policies and activities were originally delegated to the Ministry of Information Society in 2009. This period was highly influenced by the stabilization and association agreement between the European communities and their member states of the one part and the Republic of Montenegro of the other part [85]. Strategies and action plans adopted in the period after the agreement had to comply with it fully. The government of Montenegro authorized the Ministry of Information Society to design and implement the public administration reform strategy [86], which was conducted in 2011 and proposed a series of actions for the following 5 years. Consequently, within the proposed period, development was intensive and dynamic. As a key infrastructure project, the e-government portal of Montenegro [87] was published in 2011, with 12 online services available for citizens. In 2018, there were 564 services on the portal, provided by 50 institutions, most of which were related to citizens, followed by services related to legal entities [88].

A similar approach to the process of digitization of public administration has been used ever since. The government established a strategic framework while reinforcing actions through the adoption of the related laws. The previously mentioned strategy was followed by the following:

- The Strategy for the Information Society Development (2016–2020) [89];
- The Public Administration Reform Strategy in Montenegro (2016–2020) [90];
- The Cyber Security Strategy of Montenegro (2018–2021) [91]; and
- The Montenegro Digital Transformation Strategy (2022–2026) [43].

The legal framework was enforced by the law on e-government [92], the law on digital identification and digital signature [93], the law on digital documentation [94], and the law on information security [95]—as key enablers for modern administration infrastructure.

The process of digitization in general—with an additional accent on information society and public administration—was monitored by the EU through Chapter 10 of Accession Negotiation. Unfortunately, since the opening of the chapter in 2014, progress was considered "limited" in all of the reports (2020 [96], 2021 [97], and 2022 [98]). Additionally, the EU recognized an issue concerning the lack of interoperability of various IT systems within the public administration sector, especially concerning public financial management. The reports emphasized efforts toward paperless administration and programs for attracting digital nomads; however, the overall status of digitization is yet to be on an adequate level.

Based on a recent research conducted in January 2023 [99], citizens did not recognize efforts and activities in this regard enough or were recognized as dissatisfying. The research concludes that traditional public administration services are still dominant and are significantly more preferred than digital services. The survey showed that only 7.7% of the respondents were familiar with e-services. In contrast, others were partially informed (45.4%), heard about the services but were not familiar with them (37.8%), or never heard of the services at all (9.1%). There are additional findings that may cause concern as well. When asked why they decided not to use e-services, the majority of respondents answered that they did not need it (54.6%) or they did not know about its existence (24.1%). Technical knowledge in terms of digital literacy represented an issue for 18.6% of the individuals. At the same time, 17.9% did not trust the systems to finish the work, and 21.6% of people answered they preferred physical contact rather than electronic services.

The current vision of public administration digitization relies vastly on political factors and policies, as well as the stability and vision of the importance of the topic, which provides

little to no space for predictions of the future status of the field. Therefore, the strategies and legal frameworks provided within this section are potentially the only landmarks for the digitization of public administration.

11. Discussion on Future Trends

In this section, an additional discussion on future trends is provided. Although most sections separately address future trends, there are predicted and planned changes that need to be covered in more detail in order to provide a comprehensive analysis of regional development.

One of the key directions for future joint actions at the national level of Montenegro relies on digital innovation hubs—vital for enabling digital transformation, supporting small- and medium-sized enterprises (SMEs), fostering innovation, and promoting economic growth. Therefore, a key DigNest project [1] result is the newly established Digital Academic Innovation Hub [100], which can provide essential resources, expertise, and networking opportunities that help businesses and regions thrive in the digital age. As being in line with priorities defined at the national level, the fields of health and agriculture are at the primary level, while still keeping the other areas within the scope of actions.

Future trends in European agriculture will be influenced by a blend of technological advancements, environmental challenges, policy changes, and shifting consumer preferences. The key trends anticipated to impact the sector include carbon farming, which consists of a collection of practices influencing soil carbon sequestration such as cover cropping or no-till farming. A recent study [101] underscores the considerable environmental effects of on-field emissions from fertilizers and pesticides in rice cultivation, stressing the need for precise estimation methods. It suggests that adopting sustainable practices—such as incorporating straw into the soil—can enhance soil organic carbon levels and help mitigate climate change impacts in Mediterranean wetlands like L'Albufera in Spain. Another study [102] examines the potential of carbon farming strategies in organic vegetable cultivation to reduce greenhouse gas emissions and enhance sustainability by maximizing carbon sequestration and minimizing carbon emissions. It highlights the importance of implementing nature-based solutions and sustainable land management practices to transform agricultural systems into effective carbon sinks. The future of agriculture in the EU as well as in Montenegro involves biodiversity, which is in constant danger. The work of Terreira et al. [103] addresses the status, causes, and consequences of soil degradation in the European Mediterranean region, emphasizing the need for a comprehensive understanding of the various degradation processes, including physical, chemical, and biological factors. It highlights the importance of establishing a harmonized soil monitoring system to track spatial and temporal changes in soil degradation, supporting decision-making, and sustainable development goals in the region. The systematic literature review by Schils et al. [104] on permanent grasslands in Europe underscores the significance of low-intensity grassland management in optimizing essential ecosystem services. By analyzing over 70,000 papers since 1980, the study highlights the necessity of supporting sustainable permanent grassland systems and policies to maintain the multi-functionality of these ecosystems. The conflict between Russia and Ukraine is threatening biodiversity and has consequences around Europe [105,106]. With droughts and climate change, water management has become increasingly important. As indicated by recent work [107], the mean total nitrogen content in the water of the Vistula old riverbeds was approximately 8.6 mg/dm^3. Additionally, the concentration of chloride in the Biebrza floodplain lakes was significantly lower than that in the tested lakes, with an average of about 11 mg/dm^3. Further research for future technologies are as follows: data governance [108], discussing data ownership; sustainable development for organic planting [109]; concepts of hydroponic farms [110]; the EU-funded RELACS project on the prevalent use of contentious inputs such as copper, mineral oils, and antibiotics in organic farming [111]; or the EU-funded ECONUTRI project, addressing environmental impacts caused by inappropriate fertilization and farming practices [112].

Furthermore, to the general trends in research, the EU with Horizon 2020 devised a plan for the digitization of the European agricultural sector [113]. It is set to revolutionize the industry, enhancing efficiency, sustainability, and competitiveness. Technologies like AI, robotics, IoT, and 5G offer significant support to farmers and agribusinesses, streamlining the value chain and fostering better communication among stakeholders. This also creates opportunities for innovative SMEs to thrive. However, digitization can create a divide between those with and without access to advanced technologies. To ensure inclusivity, policymakers, industry leaders, and technology providers must collaborate to promote the benefits of digitization and support farmers with training, resources, and incentives. This can improve the sustainability and profitability of farming while addressing food security and climate change. IoT technology, in particular, transforms agriculture by providing real-time data on environmental and machine conditions. This aids in precision farming, leading to higher yields and reduced waste. Additionally, IoT allows remote monitoring of crops and livestock, reducing labor costs, and ensuring animal health and safety.

To align Montenegro's agriculture with EU laws, significant changes are imperative across various fronts. This includes implementing stringent food safety and quality standards, promoting sustainable farming practices to mitigate environmental impact, ensuring adherence to animal welfare regulations, and fostering rural development. Montenegro needs to harmonize its agricultural policies with the EU's common agricultural policy (CAP), adopt digital technologies for precision agriculture, and strengthen institutional capacity for effective implementation. Additionally, enhancing market access and trade, improving rural infrastructure, and investing in education and research are vital steps to ensure compliance and competitiveness in the EU market while fostering sustainable agricultural development in Montenegro.

Regarding transportation, Montenegro's efforts to embrace technological advancements in its transportation ecosystem are evident. Still, results remain somewhat sporadic, and a comprehensive strategy that includes C-ITSs for the coming years is lacking. C-ITSs are crucial for the future of transportation, particularly in terms of digitization and European-level harmonization. Digital technologies in personal and public transportation are fundamental for improving safety, efficiency, and convenience. As Montenegro charts its strategic trajectory, it should address immediate ITS needs, such as traffic safety at intersections, serpentines, and railway crossings, and also prioritize the integration of C-ITSs to leverage the broader benefits of digitization in the long term.

The challenges of a broader scale of digitization in Montenegro's transport sector—including lack of experience, coordination, and regulation structures, as well as IT-related education—must be addressed to successfully integrate ITSs into its road and rail networks. As the global landscape shifts toward digitized, smart, and interconnected transportation, Montenegro's recognition and inclusion of ITSs/C-ITSs in its strategies will be essential for encouraging innovation, enhancing safety, and ensuring a seamless digital future in the domain. By investing in digital infrastructure, improving education and training, and fostering international collaborations, Montenegro can transform its public transportation to make it safer, more efficient, and aligned with the EU and global standards.

12. Conclusions

In this paper, we provide a comprehensive study of the past 17 years of Montenegro in terms of human-centric digitization, addressing the current state and future trends of the investigated fields. While the country has achieved significant progress over these years, much remains to be done to catch up with EU countries. While most of the healthcare institutions are fully integrated into the Integral Health Information System of Montenegro, the Clinical Centre of Montenegro, the Ministry of Health, as well as certain private institutions are only partially integrated at the time of writing this paper. Regarding the digital transformation of the Montenegrin higher education system, collaborations with other universities, professional organizations, and industry partners have progressed well at the implementation level, similar to digital learning technologies, instructional modal-

ity, and learner development. However, support services, instructor development, and organizational policies and planning consistently lag behind. One major future challenge is for these areas to match the implementation levels of the more developed aspects. In terms of telecommunications, the speed of internet connection reached over 100 Mb/s for nearly two-thirds of all end-user devices by late 2023, while roughly a quarter is still between 2 Mb/s and 30 Mb/s. The country's transportation sector has undergone a noteworthy digital transformation. While there are significant efforts toward developing ITS and C-ITS across the EU, Montenegro, unfortunately, does not plan to consider C-ITS in the upcoming decade—even though C-ITS is crucial for the long-term improvement of safety and efficiency in transportation systems. Tourism—being one of the most important sectors of the country—has progressed rather well over the years, guided by national strategies, development plans, laws, regulations, and rule books that not only set requirements based on detailed classifications but also converge toward green tourism and sustainability. Agriculture has been partially transformed by the MIDAS project [69], during which, over 1500 clients adopted improved agricultural technologies and, thus, sustainable land management practices apply to more than 2000 ha of land—yet Montenegrin agriculture remains largely dependent on manual farming. Regarding the energy sectors, the country used to be heavily dependent on fossil fuels, yet wind and solar energy are steadily diversifying the national energy mix and contributing to self-sufficiency, and with the assumption of average hydrological conditions for the next year, Montenegro has the potential to become a net exporter of electricity. Finally, as highlighted by a recent study [99], less than 10% of respondents are familiar with Montenegrin digital public administration, the lack of technical competencies is a barrier for nearly 20%, and generally, there is a clear preference toward the traditional services of public administration.

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Abbreviations

The following abbreviations are used in this manuscript:

AI	artificial intelligence
AIS	automatic identification system
AR	augmented reality
C2C-CC	CAR 2 CAR Communication Consortium
CAP	common agricultural policy
CCTV	closed-circuit television
CEDR	Conference of European Directors of Roads
C-ITSs	cooperative intelligent transportation systems
DigNest	Digital Entrepreneurial Nest and Industry 4.0 in Montenegro
EBRD	European Bank for Reconstruction and Development
EC	European Commission
ECTS	European Credit Transfer and Accumulation System

EHR	electronic health record
EMSA	European Maritime Safety Agency
ERTMS	European Rail Traffic Management System
EU	European Union
EU EIP	EU ITS Platform
FAO	Food and Agriculture Organization of the United Nations
HEIs	higher education institutions
ICT	information and communication technology
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
IPA	Instrument for Pre-accession Assistance
IPARD	Instrument for Pre-accession Assistance for Rural Development programs
ISO	International Organization for Standardization
ITSs	intelligent transportation systems
LMSs	learning management systems
MEIS	Montenegrin Education Information System
MESCS	Ministry of Education, Science, Culture, and Sport
MICE	meetings, incentives, conferences/conventions, exhibitions/events
MIDAS	The Montenegro Institutional Development and Agriculture Strengthening Project
MONSTAT	Statistical Office of Montenegro
QoL	quality of life
S3	smart specialization strategy
SMEs	small- and medium-sized enterprises
TSIs	Technical Specifications for Interoperability
UNDP	United Nations Development Program
VHF	very high frequency
VR	virtual reality
VTMIS	Vessel Traffic Monitoring and Information System
WHO	World Health Organization
XR	extended reality

References

1. DigNest: Digital Entrepreneurial Nest and Industry 4.0 in Montenegro. Available online: https://dignest.me/ (accessed on 28 May 2024).
2. Kara, P.A.; Ognjanovic, I.; Maindorfer, I.; Mantas, J.; Wippelhauser, A.; Šendelj, R.; Laković, L.; Roganović, M.; Reich, C.; Simon, A.; et al. The present and future of a digital Montenegro: Analysis of C-ITS, agriculture, and healthcare. *Eng* **2023**, *4*, 341–366. [CrossRef]
3. Eurostat Interactive Publications. Digitalisation in Europe—2024 Edition. 2024. Available online: https://ec.europa.eu/eurostat/web/interactive-publications/digitalisation-2024 (accessed on 28 May 2024).
4. Mura, P.O.; Donath, L.E. Digitalisation and Economic Growth in the European Union. *Electronics* **2023**, *12*, 1718. [CrossRef]
5. European Commission. Europe's Digital Decade. 2022. Available online: https://digital-strategy.ec.europa.eu/en/policies/europes-digital-decade (accessed on 28 May 2024).
6. European Comission: Smart Specialisation Platform. Available online: https://s3platform.jrc.ec.europa.eu/montenegro (accessed on 28 May 2024).
7. European External Action Service: Key findings of the 2023 Report on Montenegro. 2023. Available online: https://www.eeas.europa.eu/delegations/montenegro/key-findings-2023-report-montenegro_en?s=225 (accessed on 28 May 2024).
8. Ministry of Health, Montenegro. Healthcare Development Strategy for the Period from 2023–2027 with the Action Plan for 2023–2024. Available online: https://wapi.gov.me/download-preview/9421207d-33f1-4ad0-98aa-083cdd6264b4?version=1.0 (accessed on 28 May 2024).
9. Tošić, B.; Đurić, D.; Sekulić, R.; Simićević, J. Cloud cOmputing Solutions for Healthcare System in ME: Challenges and Issues. 2017. Available online: https://www.it.ucg.ac.me/upload/files/zbornici/Zbornik%20IT17.pdf (accessed on 28 May 2024).
10. Gjellebæk, C.; Svensson, A.; Bjørkquist, C.; Fladeby, N.; Grundén, K. Management challenges for future digitalization of healthcare services. *Futures* **2020**, *124*, 102636. [CrossRef]
11. Institute of Public Health, Montenegro. Analysis of Human Resources in the Health Care System of Montenegro 2008–2018. 2019. Available online: https://s3.eu-central-1.amazonaws.com/web.repository/ijzcg-media/files/1591772227-analiza-ljudskih-resursa-2019.pdf (accessed on 28 May 2024).
12. Šendelj, R. Information technology and information management in healthcare. In *Health Information Management: Empowering Public Health*; IOS Press: Amsterdam, The Netherlands, 2020; Volume 274, pp. 139–158.

13. Knaup, P.; Benning, N.H.; Seitz, M.W.; Eisenmann, U. eHealth and clinical documentation systems. In *Health Information Management: Empowering Public Health*; IOS Press: Amsterdam, The Netherlands, 2020; pp. 174–188.
14. Lovis, C. Health, Digital Health and Decision Support: Sisyphus and Pandora. In *Achievements, Milestones and Challenges in Biomedical and Health Informatics*; IOS Press: Amsterdam, The Netherlands, 2020; Volume 300, pp. 180–189.
15. Salahuddin, L.; Ismail, Z. Classification of antecedents towards safety use of health information technology: A systematic review. *Int. J. Med. Inform.* **2015**, *84*, 877–891. [CrossRef] [PubMed]
16. Viitanen, J.; Hyppönen, H.; Lääveri, T.; Vänskä, J.; Reponen, J.; Winblad, I. National questionnaire study on clinical ICT systems proofs: Physicians suffer from poor usability. *Int. J. Med. Inform.* **2011**, *80*, 708–725. [CrossRef] [PubMed]
17. Kaipio, J.; Lääveri, T.; Hyppönen, H.; Vainiomäki, S.; Reponen, J.; Kushniruk, A.; Borycki, E.; Vänskä, J. Usability problems do not heal by themselves: National survey on physicians' experiences with EHRs in Finland. *Int. J. Med. Inform.* **2017**, *97*, 266–281. [CrossRef]
18. Muhiyaddin, R.; Elfadl, A.; Mohamed, E.; Shah, Z.; Alam, T.; Abd-Alrazaq, A.; Househ, M. Electronic health records and physician burnout: A scoping review. In *Informatics and Technology in Clinical Care and Public Health*; IOS Press: Amsterdam, The Netherlands, 2022; pp. 481–484.
19. Johnson, K.B.; Neuss, M.J.; Detmer, D.E. Electronic health records and clinician burnout: A story of three eras. *J. Am. Med. Inform. Assoc.* **2021**, *28*, 967–973. [CrossRef]
20. Hill, C.; Lawton, W. Universities, the digital divide and global inequality. *J. High. Educ. Policy Manag.* **2018**, *40*, 598–610. [CrossRef]
21. Vial, G. Understanding digital transformation: A review and a research agenda. In *Managing Digital Transformation*; Routledge: London, UK, 2021; pp. 13–66.
22. Grajek, S.; Reinitz, B. Getting Ready for Digital Transformation: Change Your Culture, Workforce, and Technology. *Educause Review*, 8 July 2019. Available online: https://er.educause.edu/articles/2019/7/getting-ready-for-digital-transformation-change-your-culture-workforce-and-technology (accessed on 28 May 2024).
23. Ministry of Education of Montenegro; United Nations Children's Fund (UNICEF). Education System Digitalization Strategy, with the Action Plan for 2022 and 2023. 2022. Available online: https://www.unicef.org/montenegro/media/22611/file/Education%20System%20Digitalization%20Strategy.pdf (accessed on 28 May 2024).
24. Martin, F.; Xie, K. Digital Transformation in Higher Education: 7 Areas for Enhancing Digital Learning. Available online: https://er.educause.edu/articles/2022/9/digital-transformation-in-higher-education-7-areas-for-enhancing-digital-learning (accessed on 28 May 2024).
25. Xie, K.; Di Tosto, G.; Chen, S.B.; Vongkulluksn, V.W. A systematic review of design and technology components of educational digital resources. *Comput. Educ.* **2018**, *127*, 90–106. [CrossRef]
26. Joosten, T.; Lee-McCarthy, K.; Harness, L.; Paulus, R. Digital Learning Innovation Trends. *Online Learning Consortium*, 6 February 2020.
27. Xie, K.; Kim, M.K.; Cheng, S.L.; Luthy, N.C. Teacher professional development through digital content evaluation. *Educ. Technol. Res. Dev.* **2017**, *65*, 1067–1103. [CrossRef]
28. Agency for Electronic Communications and Postal Services. Available online: https://www.ekip.me/ (accessed on 28 May 2024).
29. UNDP. Human Development Report for Montenegro. Available online: https://www.undp.org/cnr/montenegro/publications/izvjestaj-o-razvoju-po-mjeri-covjeka-za-crnu-goru-za-2020-godinu-nadomak-digitalne-buducnosti-za-sve (accessed on 28 May 2024).
30. MONSTAT. Use of Information and Communication Technologies in Households and by Individuals. Available online: https://www.monstat.org/uploads/files/ICT/2023/domacinstva/Saop%C5%A1tenje%202023%20Domacinstva.pdf (accessed on 28 May 2024).
31. Report: Degree of satisfaction among users of Electronic Communication Services in Montenegro. 2023. Available online: https://www.ekip.me/page/reports/researches/content (accessed on 28 May 2024).
32. MONSTAT. Use of Information and Communication Technologies in Companies in 2023. 2023. Available online: https://www.monstat.org/uploads/files/ICT/2023/preduzeca/Saop%C5%A1tenje%202023%20Preduzeca.pdf (accessed on 28 May 2024).
33. WIPO. Global Innovation Index 2023, Innovation in the Face of Uncertainty, 16th Edition. Available online: https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2023-en-main-report-global-innovation-index-2023-16th-edition.pdf (accessed on 28 May 2024).
34. Ministry of Economic Development. *Spatial Plan of Montenegro until 2020*; Ministry of Economic Development: Warsaw, Poland, 2008.
35. Digital Public Administration Factsheet 2022 Montenegro. Available online: https://joinup.ec.europa.eu/sites/default/files/inline-files/DPA_Factsheets_2022_Montenegro_vFinal_0.pdf (accessed on 28 May 2024).
36. Nikčević, J.; Škurić, M. A contribution to the sustainable development of maritime transport in the context of blue economy: The Case of Montenegro. *Sustainability* **2021**, *13*, 3079. [CrossRef]
37. Preparation of the Transport Development Strategy—Montenegro (Contract No. 829-4147). In *Transport Development Strategy Report*; European Commission: Brussels, Belgium 2017.
38. List of Cities in Montenegro by Population, 2022. Available online: https://all-populations.com/en/me/list-of-cities-in-montenegro-by-population.html (accessed on 28 May 2024).
39. WHO. Death on the Roads—Based on the WHO Global Status Report on Road Safety 2018. Available online: https://extranet.who.int/roadsafety/death-on-the-roads/#country_or_area/MNE (accessed on 28 May 2024).

40. Level Crossing—Current Situation in the Western Balkan Region, Statistics, Classification and Comparison on LCs within Western Balkan. Available online: https://www.transport-community.org/wp-content/uploads/2019/12/TCT-Railroad-level-crossingsV2.pdf (accessed on 28 May 2024).
41. Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the Framework for the Deployment of Intelligent Transport Systems in the Field of Road Transport and for Interfaces with Other Modes of Transport. 2010. Available online: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32010L0040 (accessed on 28 May 2024).
42. Stathopoulos, A.; Kepaptsoglou, K. Transport Development Strategy—Montenegro 2019–2035. 2019. Available online: https://wapi.gov.me/download/a080d54d-0b87-4d8c-bfbf-bdc8ae5dc8bb?version=1.0 (accessed on 28 May 2024).
43. Minsitry of Public Administration, Digital Society and Media, Government of Montenegro. Montenegro Digital Transformation Strategy 2022–2026 with Action Plan 2022–2023. 2021. Available online: https://wapi.gov.me/download/59dcab9b-b0e8-48b7-830b-6e4eab690521?version=1.0 (accessed on 28 May 2024).
44. C-ROADS. C-Roads—The Platform of Harmonised C-ITS Deployment in Europe. 2022. Available online: https://www.c-roads.eu/platform.html (accessed on 28 May 2024).
45. Prelevic, M. Management of Transport Processes with the use of Intelligent Transport Systems—A Case Study of the Company Vertigo Montenegro Ltd.—Podgorica. *Glob. J. Res. Eng.* **2020**, *20*, 11–15. [CrossRef]
46. Government of Montenegro. Programme for the Development and Introduction of Intelligent Transport Systems in Road Traffic 2022–2026. Available online: https://media.institut-alternativa.org/2023/09/From-Egovernemnt-do-digital-transformation-An-overview-of-key-challenges-in-Montenegro.pdf (accessed on 28 May 2024).
47. Institute Alternative. From eGovernment to Digital Transformation: An Overview of Key Challenges in Montenegro. 2023. Available online: https://wapi.gov.me/download/c9b0c7f3-7d34-43f4-8c57-b1038891ad14?version=1.0 (accessed on 28 May 2024).
48. MONSTAT. Montenegro in Figures 2022. 2022. Available online: https://www.monstat.org/uploads/files/publikacije/monstat%20eng%20final.pdf (accessed on 28 May 2024).
49. Central Bank of Montenegro. CBCG Annual Macroeconomic Report 2021. 2022. Available online: https://www.cbcg.me/slike_i_fajlovi/fajlovi/fajlovi_publikacije/godisnji_makro_izvjestaj/2021/eksterni_sektor.pdf (accessed on 28 May 2024).
50. MONSTAT. Gross Domestic Product Montenegro 2021. 2022. Available online: https://www.monstat.org/uploads/files/BDP/2021/Godisnji%20BDP%202021_crn.pdf (accessed on 28 May 2024).
51. Bickert, M.; Göler, D.; Lehmeier, H. Coastal tourism in Montenegro—Economic dynamics, spatial developments and future perspectives. *Hrvat. Geogr. Glas.* **2011**, *73*, 165–180. [CrossRef]
52. Dasic, N.; Jovicic, D. Selective forms of tourism in Montenegro. *Bull. Serbian Geogr. Soc.* **2011**, *91*, 135–157. [CrossRef]
53. Adžić, S.; Žižić, M. Structural changes in the economy of Montenegro and the development of its tourism. *Ekon. Izazovi* **2016**, *5*, 8–24. [CrossRef]
54. Peković, S.; Vukčević, J.; Stanovčić, T.; Perović, Đ. New Geographies of Tourist Consumption: The Case of Montenegro. In Proceedings of the ENTRENOVA—ENTerprise REsearch InNOVAtion Conference, Dubrovnik, Croatia, 7–9 September 2017; Volume 3, pp. 196–200.
55. MONSTAT. Arrivals and Overnight Stays of Tourists 2021. 2022. Available online: https://monstat.org/uploads/files/TURIZAM/ukupno/2021/Dolasci%20i%20no%C4%87enja%20turista%2C%20ukupno%2C%202021.%20godina%20(3).pdf (accessed on 28 May 2024).
56. MONSTAT. Gross Domestic Product Montenegro 2007. 2008. Available online: http://monstat.org/userfiles/file/GDP/GDP-%202007.zip (accessed on 28 May 2024).
57. Parfinenko, A. "The Russian World" on the Budva Riviera: Tourism and Foreign Policy Process in the Montenegro. *Actual Probl. Int. Relations* **2020**, *1*, 27–40. [CrossRef]
58. Ratkovic, R.; Bulatović, I. Impact of economic crisis on sustainable tourism (Case: Montenegro). In Proceedings of the Tourism in Southern and Eastern Europe, Opatija, Croatia, 15–18 May 2013; pp. 355–370.
59. Central Bank of Montenegro. Analysis of the Effects of Tourism on the GDP, Employment and Balance of Payments of Montenegro. 2011. Available online: https://www.cbcg.me/slike_i_fajlovi/fajlovi/fajlovi_publikacije/radne_studije/analiza_efekata_turizma.pdf (accessed on 28 May 2024).
60. Micić, J.; Denda, S.; Petrović, M.D. Tourism Policy in Montenegro—Current Situation and Future Challenges. In Proceedings of the Book of Proceedings of 7th International Congress "Hospitality as a Quality Factor of Tourist Destination Offer and Competitiveness-HOTELPLAN 2018", Belgrade, Serbia, 2–3 November 2018; College of Hotel Management: Belgrade, Serbia, 2018; pp. 481–489.
61. Government of Montenegro. Law on Tourism and Hospitality. 2021. Available online: https://www.gov.me/dokumenta/e21ecba9-b1da-4d70-8c61-e55ba303726c (accessed on 28 May 2024).
62. Government of Montenegro. Rulebook on Types, Minimum Technical Conditions and Categorization of Hospitality Establishments. 2018. Available online: https://www.gov.me/dokumenta/963eecfd-6dc6-46e8-b75d-d44dd7f3c3d7 (accessed on 28 May 2024).
63. Government of Montenegro. Standards for Categorization, General, Mandatory and Qualitative Standards for Hotel, Small Hotel, Garni Hotel, Apart Hotel, Tourist Resort, Hotel & Resort, Condo Hotel, Boarding House, Inn. 2013. Available online: https://www.gov.me/dokumenta/82e1820a-6bf7-46ea-be14-b7a8261c6bd1 (accessed on 28 May 2024).

64. Government of Montenegro. Proposal for a Law on Tourism and Hospitality with a Report on the Public Debate. 2023. Available online: https://www.gov.me/dokumenta/d46d3e1a-f3d3-4796-bd2c-18198f7c010d (accessed on 28 May 2024).
65. Government of Montenegro. Digital Transformation Strategy for the Development of Digital Montenegro. 2021. Available online: https://www.gov.me/clanak/strategija-digitalne-transformacije-za-razvoj-digitalne-crne-gore (accessed on 28 May 2024).
66. Government of Montenegro. Program of Economic Reforms of Montenegro 2022–2024. 2022. Available online: https://www.gov.me/dokumenta/e75a225c-375c-47bb-af21-5b595523b305 (accessed on 28 May 2024).
67. European Commission. Agriculture and Rural Development. 2019. Available online: https://agriculture.ec.europa.eu/international/international-cooperation/enlargement/candidates_en (accessed on 28 May 2024).
68. farmwithscience.org. Available online: http://www.farmwithscience.org/files/articles_pdf/viticulture/agriculture_in_montenegro_investment_opportunities.pdf (accessed on 28 May 2024).
69. The World Bank. The MIDAS Touch: Supporting Institutional and Agricultural Development in Montenegro. 2020. Available online: https://www.worldbank.org/en/results/2020/10/11/supporting-institutional-and-agricultural-development-in-montenegro (accessed on 28 May 2024).
70. *ISO/IEC 17025:2017*; General Requirements for the Competence of Testing and Calibration Laboratories. ISO: Geneva, Switzerland, 2017.
71. The Viral Project. Vitalising ICT Relevance in Agricultural Learning. 2021. Available online: http://viralerasmus.org/en/home/# (accessed on 28 May 2024).
72. The DIPOL Project. Digital Transformation of Agriculture and Food Supply Chain in Montenegro. 2021. Available online: https://dipol.udg.edu.me/site/ (accessed on 28 May 2024).
73. European Bank for Reconstruction and Development. EBRD and FAO Boost the Digitalisation of Agribusiness in Montenegro. 2021. Available online: https://www.ebrd.com/news/2021/ebrd-and-fao-boost-the-digitalisation-of-agribusiness-in-montenegro.html (accessed on 28 May 2024).
74. Wageningten University & Research. Precision Agriculture—Smart Farming. 2023. Available online: https://www.wur.nl/en/dossiers/file/dossier-precision-agriculture.htm (accessed on 28 May 2024).
75. Vagisha.; Rajesh, E.; Basheer, S.; Baskar, K. Hydroponics Soilless Smart Farming in Improving Productivity of Crop Using Intelligent Smart Systems. In Proceedings of the 2023 3rd International Conference on Innovative Practices in Technology and Management (ICIPTM), Uttar Pradesh, India , 22–24 February 2023; pp. 1–6. [CrossRef]
76. Sustainability in the Digital Age Concordia University. Data Driven Insights for Sustainable Agriculture (DISA). 2023. Available online: https://sustainabilitydigitalage.org/featured/data-driven-insight-for-sustainable-agriculture-disa/ (accessed on 28 May 2024).
77. TS2 SPACE. AI in Agriculture: Empowering Farmers with Data-Driven Insights. 2023. Available online: https://ts2.space/en/ai-in-agriculture-empowering-farmers-with-data-driven-insights/ (accessed on 28 May 2024).
78. 365FarmNet GmbH. 365FarmNet Areas of Application. 2023. Available online: https://www.365farmnet.com/en/areas-of-application/ (accessed on 28 May 2024).
79. Government of Montenegro, Ministry of Economy. Energy Policy of Montenegro until 2030. 2011. Available online: https://www.gov.me/dokumenta/a720f4d0-c652-44e9-aeb9-811ea296be3a (accessed on 28 May 2024).
80. Government of Montenegro. Energy Balance of Montenegro for 2022. 2021. Available online: https://www.gov.me/dokumenta/5fe82480-023b-431a-b8fb-57d67098aada (accessed on 28 May 2024).
81. Government of Montenegro, Ministry of Economy. Energy Development Strategy of Montenegro until 2030. 2014. Available online: https://wapi.gov.me/download/f0a01d7a-478d-4e57-93c8-afeb0375b591?version=1.0 (accessed on 28 May 2024).
82. Government of Montenegro. Information on the Initiation of Proceedings against Montenegro by the Secretariat of the Energy Community. 2021. Available online: https://www.gov.me/dokumenta/d9e85b40-7b0c-4625-9ba4-5a860fa3b737 (accessed on 28 May 2024).
83. Regulatory Agency for Energy and Regulated Utilities. Report on the State of the Energy Sector of Montenegro for 2021. 2022. Available online: https://zakoni.skupstina.me/zakoni/web/app.php/akt/2907 (accessed on 28 May 2024).
84. Government of Montenegro, Ministry of Economy. National Action Plan for the Use of Energy from Renewable Sources until 2020. 2014. Available online: https://wapi.gov.me/download/6d8db09e-a2b1-4e4a-bf98-42c39a0b3299?version=1.0 (accessed on 28 May 2024).
85. EUR-Lex. Stabilisation and Association Agreement with Montenegro. 2022. Available online: https://eur-lex.europa.eu/EN/legal-content/summary/stabilisation-and-association-agreement-with-montenegro.html (accessed on 28 May 2024).
86. Government of Montenegro. Public Administration Reform Strategy in Montenegro for the Period 2011–2016. 2011. Available online: https://www.gov.me/en/documents/d618be75-5c3f-4308-b809-14bf90753a05 (accessed on 28 May 2024).
87. eGovernment Portal of Montenegro. Available online: https://www.euprava.me/ (accessed on 28 May 2024).
88. Government of Montenegro. Analysis of the State of Electronic Administration in Montenegro. 2018. Available online: https://www.gov.me/dokumenta/6e96b0b1-0523-4d38-ab07-ef4a34bee2d9 (accessed on 28 May 2024).
89. Ministry for Information Society and Telecommunications, Government of Montenegro. Strategy for the Information Society Development 2016–2020. 2016. Available online: https://wapi.gov.me/download/68736414-503b-41bb-81b0-753b581fb386?version=1.0 (accessed on 28 May 2024).

90. Government of Montenegro. Public Administration Reform Strategy in Montenegro 2016–2020. 2016. Available online: https://wapi.gov.me/download/1a107a62-5961-4c9e-b8ce-8c8c652549e2?version=1.0 (accessed on 28 May 2024).
91. Government of Montenegro. Cyber Security Strategy of Montenegro 2018–2021. 2018. Available online: https://www.gov.me/dokumenta/fa4f3ed4-d059-4958-8847-d6111360a477 (accessed on 28 May 2024).
92. Government of Montenegro. Law on Electronic Administration. 2020. Available online: https://www.gov.me/en/documents/0ee38c03-d492-462c-937b-f2a029bc58ad (accessed on 28 May 2024).
93. Government of Montenegro. Law on Electronic Identification and Electronic Signature. 2020. Available online: https://www.gov.me/en/documents/040e9f79-f385-49bd-9773-6a77cb7e8f40 (accessed on 28 May 2024).
94. Government of Montenegro. The Law on Electronic Documents. 2023. Available online: https://www.gov.me/en/documents/f5081468-2472-429f-9b91-494a36e2dce3 (accessed on 28 May 2024).
95. Government of Montenegro. Draft Law on Information Security. 2023. Available online: https://www.gov.me/en/documents/e0bbdb63-8f15-4b79-8833-9390f286d7a1 (accessed on 28 May 2024).
96. Directorate-General for Neighbourhood and Enlargement Negotiations. Montenegro Report 2020. 2020. Available online: https://neighbourhood-enlargement.ec.europa.eu/montenegro-report-2020_en (accessed on 28 May 2024).
97. Directorate-General for Neighbourhood and Enlargement Negotiations. Montenegro Report 2021. 2021. Available online: https://neighbourhood-enlargement.ec.europa.eu/montenegro-report-2021_en (accessed on 28 May 2024).
98. Directorate-General for Neighbourhood and Enlargement Negotiations. Montenegro Report 2022. 2022. Available online: https://neighbourhood-enlargement.ec.europa.eu/montenegro-report-2022_en (accessed on 28 May 2024).
99. Ministry of Public Administration. Digitalization of Public Administration: Assessment of Satisfaction with Existing and Identification of Needs for New E-Services. 2023. Available online: https://www.undp.org/sites/g/files/zskgke326/files/2023-04/Digitalizacija%20javne%20uprave%20-%20istrazivanje%20sa%20gradjanima%202022-23.pdf (accessed on 28 May 2024).
100. DAIH: Digital Academic Innovation Hub. Available online: https://daih.me/ (accessed on 28 May 2024).
101. Moreno-Ramón, H.; Ulzurrun, J.; Lidon, A.; Sanjuán, N. Assessing the environmental impacts of rice in an anthropized Mediterranean wetland: Towards carbon farming. *Sustain. Prod. Consum.* **2024**, *45*, 476–487. [CrossRef]
102. Avasiloaiei, D.I.; Calara, M.; Brezeanu, P.M.; Gruda, N.S.; Brezeanu, C. The Evaluation of Carbon Farming Strategies in Organic Vegetable Cultivation. *Agronomy* **2023**, *13*, 2406. [CrossRef]
103. Ferreira, C.S.; Seifollahi-Aghmiuni, S.; Destouni, G.; Ghajarnia, N.; Kalantari, Z. Soil degradation in the European Mediterranean region: Processes, status and consequences. *Sci. Total. Environ.* **2022**, *805*, 150106. [CrossRef]
104. Schils, R.L.; Bufe, C.; Rhymer, C.M.; Francksen, R.M.; Klaus, V.H.; Abdalla, M.; Milazzo, F.; Lellei-Kovács, E.; ten Berge, H.; Bertora, C.; et al. Permanent grasslands in Europe: Land use change and intensification decrease their multifunctionality. *Agric. Ecosyst. Environ.* **2022**, *330*, 107891. [CrossRef]
105. Pereira, P.; Bašić, F.; Bogunovic, I.; Barcelo, D. Russian-Ukrainian war impacts the total environment. *Sci. Total. Environ.* **2022**, *837*, 155865. [CrossRef] [PubMed]
106. Rawtani, D.; Gupta, G.; Khatri, N.; Rao, P.K.; Hussain, C.M. Environmental damages due to war in Ukraine: A perspective. *Sci. Total. Environ.* **2022**, *850*, 157932. [CrossRef]
107. Gmitrowicz-Iwan, J.; Ligęza, S. Floodplain lakes as an indicator of increasing industrial pollution–Case study from a fertilizer factory in Poland. *Environ. Res.* **2023**, *238*, 117278. [CrossRef] [PubMed]
108. Atik, C. Towards comprehensive European agricultural data governance: Moving beyond the "data ownership" debate. *IIC Int. Rev. Intellect. Prop. Compet. Law* **2022**, *53*, 701–742. [CrossRef]
109. Kowalska, A.; Bieniek, M. Meeting the European green deal objective of expanding organic farming. *Equilib. Q. J. Econ. Econ. Policy* **2022**, *17*, 607–633. [CrossRef]
110. Barghash, M.A.; Shurbaji, T.R.; Romman, R. Applying Operation Research Methodologies to Hydroponic Crop Scheduling in a Closed System: An Integer Programming Approach. *Open Agric. J.* **2023**, *17*, 1–3. [CrossRef]
111. Varga, K.; Fehér, J.; Trugly, B.; Drexler, D.; Leiber, F.; Verrastro, V.; Magid, J.; Chylinski, C.; Athanasiadou, S.; Thuerig, B.; et al. The state of play of copper, mineral oil, external nutrient input, anthelmintics, antibiotics and vitamin usage and available reduction strategies in organic farming across Europe. *Sustainability* **2022**, *14*, 3182. [CrossRef]
112. Savvas, D.; Giannothanasis, E.; Ntatsi, G. Precise fertilization in greenhouse crops using modern decision support systems to save fertilisers and mitigate pollution of water resources. *Acta Hortic.* **2024**, *97*, 723–734. [CrossRef]
113. European Commission. The Digitalisation of the European Agricultural Sector. 2023. Available online: https://digital-strategy.ec.europa.eu/en/policies/digitalisation-agriculture (accessed on 28 May 2024).