Summary Report of the EDP to the Strategy

SK RIS3 2021+

RESEARCH AND INNOVATION AUTHORITY

Content

List of Abbreviations

ACS	Academic Clinical Trials
AI	Artificial Intelligence
AKIS	Agricultural Knowledge and Innovation System
BBMRI	Biobanking and Biomolecular Resources Research Infrastructure
CBE JU	Circular Bio-based Europe Joint Undertaking
CVTI SR	Slovak Centre of Scientific and Technical Information
DPMO	Deputy Prime Minister's Office for the Recovery Plan and the Knowledge Economy
EATRIS	European Research Infrastructure for Translational Medicine
ECRIN	European Clinical Research Infrastructure Network
EDP	Entrepreneurial Discovery Process
EIP OG	European Innovation Partnership Operational Groups
ELIXIR	European Life-Sciences Infrastructure for Biological Information
EMBL	European Molecular Biology Laboratory
ESFRI	European Strategy Forum on Research Infrastructures
ESIF	European Structural and Investment Funds
EU	European Union
EU-27	Current EU Member States after UK's exit
GDP	Gross Domestic Product
HC	Healthcare
HE	Horizon Europe
HEI	Higher education institutions
HTA	Health Technology Assessment
IPCEI	Important Projects of Common European Interest
IPR	Intellectual Property Rights
KS	Clinical Trials
MP SR	Ministry of Agriculture and Rural Development
MHSR	Ministry of Economy of the Slovak Republic
MZ SR	Ministry of Health of the Slovak Republic
MIRRI SR	Ministry of Investments, Regional Development and Informatization of the Slovak Republic
MŽP SR	Ministry of Environment of the Slovak Republic
NIHO	National Institute for Health Technology Assessment
NOI	National Oncology Institute
NOP	National Oncology Programme
NOU	National Oncology Institute
OECD	Organization for Economic Co-operation and Development
OKS	Clinical Trial Department
R&D	Research and Development
RDI	Research, Development and Innovation
S3	Research and Innovation Smart Specialisation Strategy
SK RIS3 2021+	Research and Innovation Smart Specialisation Strategy of the Slovak Republic 2021–2027
SLOVACRIN	Slovak Clinical Research Infrastructure Network
SME	Small and Medium Enterprises

SR	Slovak republic
UN	United Nations
V4	Visegrád Group (Czechia, Hungary, Poland, Slovakia)
WHO	World Health Organization
WIPO	World Intellectual Property Organization

Glossary

General Terms	
Innovation	Innovation is a new or improved product or process (or a combination thereof) that differs significantly from previous products or processes and that has been made available to potential users (product) or implemented (process).
Applied Research	Applied research is original research undertaken with the aim of acquiring new knowledge. However, it is primarily directed toward a specific, practical objective or purpose. The results of applied research are intended mainly to be valid for one or a limited number of products, operations, methods, or systems. Applied research gives ideas an operational form. The knowledge or information obtained is often patented but may also be kept confidential.
Patent	A patent is a protective document by which the relevant patent office grants the patent holder the exclusive right to use an invention for a specified period within a defined geographical area. The conditions for granting a patent are regulated by law, and a patent may be granted for inventions in all fields of technology, provided that the invention is new, involves an inventive activity and is capable of industrial application. Based on the granted patent, the patent holder obtains the exclusive right to use the invention during the validity of the patent and to commercialize their rights, for example by granting permission for its use (licensing), transferring the patent to another person, or establishing a lien on the patent.
1. Innovative Industry for the 21st century	
Robots and Advanced Robots	A robot is an actuated mechanism programmable in two or more axes with a certain degree of autonomy, moving within its environment to perform intended tasks. Advanced robotics includes robots with a higher level of autonomy, intelligence, and adaptability, often incorporating artificial intelligence, sophisticated sensors, and advanced actuators to carry out complex tasks in dynamic environments.
Data Collection from Devices and Processes Using Sensors	The process of acquiring information about the status and behavior of devices and processes through sensors that measure physical quantities and convert them into digital data. This data supports optimization, predictive maintenance, and integration into intelligent systems within the framework of Industry 4.0.
Breakthrough/Completely New Technologies	Fundamental technological innovations that enhance competitiveness, added value, and production quality.
Smart materials	Smart materials (intelligent materials) adaptively respond to changes in the external environment (e.g., temperature, pressure, electric field) by altering their properties. This capability enables their use in sensors, actuators, and adaptive systems.

Intelligent and Autonomous Networks	Intelligent networks minimize human intervention by leveraging automation, artificial intelligence, and real-time data analysis to optimize performance and adaptability. Autonomous networks additionally possess the ability to self-manage, monitor, and -adapt according to predefined goals through features such as self-configuration, -diagnostics, -repair, and -optimization. These networks utilize intelligent decision-making processes and automated agents for efficient and effective operation.
Renewable Energy Sources	Energy from renewable non-fossil sources, including wind, solar (solar thermal and photovoltaic), and geothermal energy, osmotic energy, ambient energy, tidal energy, wave energy and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas, and biogas.
Biomaterials	Any material that interacts with biological systems for a medical purpose, whether therapeutic (for treatment) or diagnostic (for diagnosis).
Biotechnologies	The application of science and technology to living organisms, as well as their parts, products, and models, with the aim of transforming living or non-living materials into the production of knowledge, goods, and services.
2. Mobility for the 21st century	
Mobility	Mobility is the ability of people and goods to move efficiently and safely between different locations.
Transport	Transport includes all forms of moving people and goods, including road, rail, air, water, and their combinations.
Logistics	Logistics is a complex process of managing the flow of goods, information, and other resources—including energy and people—between the point of origin and the point of consumption to meet the requirements of end users.
Multimodal transport	Multimodal transport integrates various modes of transport (road, rail, air, water) into a single transport chain with the aim of optimizing efficiency, reducing costs, and minimizing environmental impact.
Multimodal hubs/nodes	Multimodal hubs are key infrastructure points that enable connection and transfer between different modes of transport, such as rail, road, air, and water transport.
Intelligent and Autonomous Mobility	Intelligent and autonomous mobility represents a complex transport system that integrates digital technologies and innovative solutions with the aim of optimizing the efficiency, accessibility, and sustainability of transportation. A key element is connectivity and automation, where vehicles achieve various levels of autonomy (defined by the 5 levels of autonomy according to SAE J3016). Autonomous and connected vehicles communicate not

	only with each other but also with transport infrastructure, thereby achieving enhanced safety by minimizing human error and enabling predictive control to reduce the risk of accidents; greater efficiency through traffic flow optimization and congestion reduction; and an improved user experience thanks to more comfortable and efficient travel. It includes the development of autonomous vehicles and intelligent transport infrastructure.
Automated Vehicles	Automated vehicles are equipped with systems that take over partial or full control of driving, thereby reducing the need for driver intervention. They are classified into 5 levels of automation according to SAE J3016.
Modular Transport Systems	Modular transport systems are based on standardized, interchangeable components (modules) that enable flexible configuration and adaptation to change transport needs, as well as integration of different modes of transport.
On-Demand Mobility/Logistics	A model that provides flexible transport and logistics services tailored to users' current needs, often through digital platforms.
Mobility as a Service (MaaS)	A mobility model that integrates various forms of transportation into a single digital platform, enabling users to plan, book, and pay for trips using different modes of transport.
Shared Mobility	A mobility model in which vehicles are shared among multiple users, thereby reducing the need for individual vehicle ownership.
Vehicle Subscription	A mobility model in which the user pays a regular fee for access to a vehicle (or multiple vehicles) for a certain period, without the need for ownership.
3. Digital Transformation of Slovakia	
Digital transformation	Integration of digital technologies into all components of society.
Embedded Systems	A compact computer system designed for a specific purpose within a larger mechanical or electronic device. It often serves real-time control functions in industries such as robotics, automotive, healthcare, and others.
Data and Process Visualization	A method of displaying complex situational information about the environment, often in real time. It emphasizes ergonomic and easily understandable presentation of data to facilitate user decision-making.
Virtual and augmented reality	Display systems that use the generation of additional visual information to create a virtual image or augment the normal view with virtual elements, for example, through see-through glasses with a display unit.
Natural Language Processing (NLP)	A set of techniques for processing audio recordings or text transcripts and extracting useful information for further processing through syntactic and semantic analysis, as well as generating spoken language from text. NLP applications include machine

	translation, question answering (e.g., call centers), text analysis, and more.
Digital Energy Products	Virtual products on the energy services market that, based on data processing, offer features such as dynamic commodity pricing, management and planning of production and consumption from variable sources, scheduling of storage charging (both stationary and mobile), peer-to-peer settlement of deliveries for active consumers, energy communities, microgrids, and more.
Quantum Key Distribution	Quantum cryptography is a cryptographic technology that uses principles of quantum mechanics to securely exchange encryption keys between two parties. It allows the creation of a shared random secret key known only to the communicating parties, which can then be used to encrypt and decrypt messages.
Post-Quantum Cryptography	Post-quantum encryption algorithms are cryptographic methods that cannot be broken by quantum computers due to their high computational complexity—unlike classical cryptography, which will be vulnerable to decryption using quantum computing.
Blockchain	A method of storing and verifying trusted information without the need for a central trusted entity, in which each node holds a local copy of the entire database of linked records verified by digital signatures.
Disinformation Prevention	Support for technical solutions aimed at analyzing and tracking the spread of disinformation in the information space, especially on social media. This includes the development of effective defensive measures to prevent their adverse impact on society.
Cyber Hygiene	A set of work habits and practices that reduce the likelihood and severity of cybersecurity incidents. In a broader sense, it also includes education aimed at preventing cyberbullying and other social phenomena in the online space.
Interpretation of Information Content	Processing data in all forms (text, image, sound) with the goal of extracting useful information suitable for further use. This is one of the application areas of AI.
4. Healthy Society	
Academic Clinical Testing	Clinical trials, that are not funded by pharmaceutical or biotechnological companies for commercial purposes, but rather by public organizations (typically universities or healthcare providers), aimed at advancing medicine.
Biobank	A collection/repository of biological samples and related data organized in a systematic manner for research and development purposes. It consists of a collection of biosamples linked to relevant health information (medical records, family history, lifestyle, genetic data), which are primarily stored for biomedical research purposes.

Biomedical research	Biomedical research is the study of human physiology and the treatment or understanding of diseases. It is a scientific field dedicated to investigating life processes, disease prevention, diagnosis and treatment, as well as the genetic and environmental factors related to disease and health.
Digital medicine	Digital medicine involves the use of software and algorithm-driven products to measure or intervene to improve human health. Digital medicine products may be used independently or in conjunction with drugs, biologics, devices, or other products to optimize patient care and health outcomes.
Genomics	Genomics is an interdisciplinary field of molecular biology focused on the structure, function, evolution, mapping, and editing of genomes.
Clinical trials	Systematic process used to evaluate the safety and effectiveness of new treatments, drugs, or technologies in humans. It is a type of research study that tests new medical approaches in people, including novel methods of screening, prevention, diagnosis, or treatment of diseases.
Clinical Studies	These studies involve drugs, devices, or other interventions. They are research projects focused on evaluating the safety, efficacy, and side effects of new treatment methods, medications, medical technologies, or diagnostic procedures in humans. These studies are essential for the development of new diagnostic and therapeutic approaches and aim to generate the evidence necessary for the approval and implementation of new treatment options in clinical practice. Although these studies may provide direct benefits to patient volunteers, their primary goal is to scientifically demonstrate the effects and limitations of experimental treatments. Clinical studies are interventional in nature and include investigational drugs, whereas clinical trials may include both interventional and non-interventional studies, but do not include investigational drugs.
Clinical Research	A systematic research process focused on collecting and evaluating data related to human health and disease. Its aim is to improve diagnosis, treatment, and prevention of diseases through the study of the effects of new drugs, therapeutic procedures, diagnostic methods, and interventions. Clinical research may include clinical trials, but also observational studies, epidemiological research, and other types of studies that investigate health outcomes by studying people or human tissue samples to understand health and disease. Clinical research helps discover new and improved methods for detecting, diagnosing, treating, and preventing illnesses. It examines the safety and effectiveness of innovative drugs, devices, or treatment methods that have not yet been approved.

Omics metods	Studies involving the measurement of many parameters, typically genes (genomics), proteins (proteomics), lipids (lipidomics), or metabolites (metabolomics).
Preclinical Research	Preclinical research is the phase of research that precedes clinical trials and focuses on evaluating the safety and efficacy of new treatment methods, drugs, or therapeutic approaches using animal models or in vitro (laboratory-based) experiments. The goal of preclinical research is to gather sufficient evidence to support the transition to clinical trials in humans. These studies involve testing a drug on microorganisms and animal subjects to obtain data on its toxicity, pharmacokinetics, and pharmacodynamics. While preclinical research answers fundamental questions about a drug's safety, it does not replace studies on how the drug interacts with the human body.
Translational Research	Translational research is an interdisciplinary process focused on applying knowledge from basic research to clinical practice. Its goal is to accelerate the transfer of discoveries from the laboratory into effective treatments, diagnostic methods, or preventive strategies that can be applied directly to patients.
5. Food Competitiveness and Climate Resilience	
Adaptation to climate change in agriculture and forestry	Adaptation to climate change involves adjusting to new climatic conditions by modifying cultivation techniques, selecting suitable crops, and implementing methods for efficient water management in agriculture. In forestry, it means adapting management practices based on ecosystem changes, particularly in the context of rising temperatures and extreme weather events.
Agroforestry	Agroforestry is an integrated land-use approach that combines the cultivation of agricultural crops or livestock with the planting of trees. This approach enhances biodiversity, improves soil fertility, regulates the water cycle, and reduces erosion, thereby contributing to sustainable agriculture and climate protection.
Bioeconomy	Bioeconomy refers to an economic system that utilizes renewable biological resources—such as plants, animals, and microorganisms—along with technologies to produce food, energy, and materials in a sustainable way. It emphasizes the efficient use of natural resources, waste minimization, and the reduction of environmental impacts while fostering innovation and economic growth. The bioeconomy spans various sectors, including agriculture, forestry, fisheries, food production, and biotechnology, with the aim of creating a sustainable framework that balances economic development with ecological approaches. By transitioning to a bioeconomy, societies can support the circular economy, enhance food security, and contribute to combating climate change.

Biotechnologies in the food industry	Biotechnologies use biological systems, organisms, or their derivatives to create or modify food products and processes. In the food industry, biotechnology is applied, for example, in the development of genetically modified crops, fermentation processes, and the production of plant-based proteins.
Organic Farming	Organic farming is a system of agricultural production management that emphasizes the use of ecological cultivation and breeding methods, minimizes the use of chemicals, promotes biodiversity, and contributes to environmental protection. This system is considered an important tool for increasing the sustainability of food systems.
Ecosystem Services	Ecosystem services are the benefits that people obtain from ecosystems. In agricultural and forest landscapes, these include climate regulation, flood protection, soil fertility, crop pollination, and the provision of timber. Proper ecosystem management is essential for their sustainability and for adapting to climate change.
Sustainable Forest Management	Integrated forest management is a principle of using and protecting forest resources in a way that maintains their biodiversity, productivity, and ability to provide ecosystem services over the long term. This approach includes forest restoration, reducing CO_2 emissions through carbon sequestration in forest ecosystems, and promoting sustainable logging methods.
Climate-Smart Agriculture	This is an approach to transforming agriculture in response to climate change. It promotes increased productivity, adaptation to climate change, and reduction of greenhouse gas emissions. In practice, it includes new agricultural practices, technologies for more efficient water management, and innovative methods for cultivating climate-resilient crops.
Living Labs	Living Labs are real-life environments where innovative solutions and technologies are tested in collaboration with end users. In the fields of food and agriculture, they serve to test new methods such as sustainable production processes, and involve direct participation of farmers, food producers, and researchers.
Circular Economy	The circular economy is a model of production and consumption that promotes waste reduction and the maximization of resource use. In the food industry, this means minimizing food waste, utilizing by-products, and reusing materials from food production—such as through composting or biogas generation.
Soil Conservation	Soil protection involves practices that safeguard soil from erosion, degradation, and nutrient depletion. Common methods include afforestation, mulching, and the use of cover crops, which help maintain soil structure and support biodiversity in agricultural landscapes.

Regenerative Agriculture	Regenerative agriculture focuses on restoring and enhancing soil quality through techniques that promote biodiversity, improve water management, and support natural nutrient cycles. This method is considered a tool in combating climate change, as it helps to fix carbon in the soil.
Soil Carbon Sequestration	This process involves storing carbon from the atmosphere in the soil through natural biological processes, such as photosynthesis, and through agricultural techniques that promote the formation of organic matter in the soil. Soil carbon sequestration is considered an important tool in the fight against climate change.

Executive Summary

The update of the Summary Report of the EDP to the Strategy SK RIS3 2021+ (hereinafter referred to as the "Summary Report") represents a commitment to the European Commission to ensure a continuous process of updating the areas of smart specialization in line with the methodology of the Entrepreneurial Discovery Process (hereinafter referred to as the "EDP"). The EDP is based on the continuous involvement of stakeholders who bring essential expertise to the approach and, together with visionaries and domain coordinators, act as a non-isolated ecosystem with a direct impact on all sectors of the national economy, including the public sphere and government.

A key systemic criterion in the currently valid Summary Report was the condition to maintain the EDP based on regular updates of the document. This framework ensures the ability to respond more flexibly to potential developments within the individual priority areas of smart specialization domains. The principle for updating is primarily based on a data-driven approach to decision-making on narrowing or expanding the areas of smart specialization.

The aim of updating the Summary Report for the period 2025–2027 is to reflect global and market changes in both national and international contexts that have occurred since the adoption of the currently valid Summary Report in 2021. The updated Summary Report also aims to more effectively direct all available financial resources to research, development, and innovation from the Slovakia Programme (hereinafter referred to as “PSK 2021–2027”), the state budget, and other possible funding sources.

The structure of the updated Summary Report builds upon the current version of the document, but it is adapted to simplify the preparation of thematically oriented calls under PSK 2021–2027, considering the limited timeframe of the current programming period. The basic concept of the document remains consistent with the “Methodological Guidance for Assessing Compliance of Calls with SK RIS3 2021+” (hereinafter referred to as the “Methodological Guidance for SK RIS3 2021+”), which is applied when evaluating calls that require alignment with SK RIS3 2021+.

The updated Summary Report is divided into two main parts. The introductory section is dedicated to the EDP methodology, describing the approach to identifying updated domains, their priority areas, transformational goals, and thematic areas of project support. The second part of the document specifies the updated text of the individual Smart Specialization Domains.

Until the government approval of the updated Summary Report of the EDP process to the Strategy SK RIS3 2021+, the currently valid Summary Report (approved by Government Resolution No. 1/25 of 10 May 2022) remains the binding document for the implementation of investments from PSK 2021–2027 (Policy Objective 1, Specific Objectives 1.1 and 1.4) in the area of smart specialization domains and their priority areas.

Upon government approval of the updated Summary Report of the EDP process to the Strategy SK RIS3 2021+, the document becomes binding for the implementation of grant funding (including financial instruments) for research, development, and innovation under PSK 2021–2027, funding from the state budget within the National Strategy for Research, Development and Innovation 2030, the Recovery and Resilience Plan, and other potential funding sources. Its content will become a condition for ensuring compliance with SK RIS3 2021+ in calls announced in the period 2025–2027.

Introduction

The updated Summary Report is an integral part of the SK RIS3 2021+ and builds upon the Summary Report of the EDP process to the Strategy SK RIS3 2021+, approved by Resolution No. 1/25 on 10 May 2022 by the Slovak Government Council for Science, Technology and Innovation.

The process of updating the Summary Report was carried out in cooperation with domain coordinators, visionaries, and members of domain working groups, comprising a total of 188 members (46 in the "Industry for the 21st Century" group, 33 in "Mobility for the 21st Century", 33 in "Digital Transformation of Slovakia", 28 in "Healthy Society", and 48 in "Food Competitiveness and Climate Resilience"), including representatives of associations, unions, companies, universities, the Slovak Academy of Sciences, and public and state administration bodies such as the Ministry of Transport of the Slovak Republic, the Ministry of Economy of the Slovak Republic, the Ministry of Investment, Regional Development and Informatization of the Slovak Republic, the Ministry of Agriculture and Rural Development of the Slovak Republic, the Ministry of Education, Research, Development and Youth of the Slovak Republic, the Ministry of Health of the Slovak Republic, and the Ministry of the Environment of the Slovak Republic.

In accordance with the currently valid wording of Act No. 575/2001 Coll. on the organization of the activities of the government and the organization of central state administration as amended (hereinafter referred to as the "Competence Act"), the Office of the Government of the Slovak Republic is responsible for fulfilling strategic and methodological coordination tasks in the field of research, development and innovation. These tasks are carried out pursuant to §24a of the Competency Act by the Deputy Prime Minister's Office for the Recovery Plan and the Knowledge Economy (DPMO), through Research and Innovation Authority (VAIA) as its organizational unit. The DPMO is responsible for managing and implementing two key national strategic documents in the field of research, development and innovation: namely, the Research and Innovation Smart Specialisation Strategy of the Slovak Republic 2021-2027 (hereinafter "SK RIS3 2021+") and the National Strategy for Research, Development and Innovation 2030 (hereinafter "National RDI Strategy"). Based on these competencies, the ODPM is the designated managing authority of the SK RIS3 2021+ strategy and is responsible for meeting its essential condition[1], as well as for coordinating activities that underpin the update of the Summary Report through revisions of domain priority areas, transformational goals, and thematic support areas, which are to guide funding allocations for the 2025 - 2027 period.

The updated Summary Report is structured into two chapters:

- The chapter "Methodology for Updating the Summary Report of the EDP process to the Strategy SK RIS3 2021+" describes the methodology and process of updating domain priority areas of smart specialization, the sequence of steps, and the timeline of their implementation, which resulted in the updated version of the document.
- The chapter "Smart Specialization Domains" was updated in cooperation with domain coordinators, visionaries, and other key stakeholders with the necessary expertise in each field. The text for the domains summarizes the goals of each domain across its priority areas with a more detailed description of their transformational objectives, as in the original version of the Summary Report. The EDP process led to the update of the smart specialization domain texts, their priority areas, and transformational goals, and resulted in a revised structure of the transformational map, which now includes data inputs

[1] The update and implementation of the Research and Innovation Smart Specialisation (hereinafter referred to as "RIS3") is essential to meet the criteria of the basic condition "Good governance of the national or regional smart specialization strategy." Meeting the criteria of this basic condition is a prerequisite for drawing financial resources and implementing part of the activities of Political Objective 1, "A more competitive and smarter Europe through promoting innovative and smart transformation of the economy and regional ICT connectivity," within the Partnership Agreement for Slovakia 2021-2027 (PSK 2021-2027).

for the updated current state situation, from which the target state and thematic support areas for research, development, and innovation are defined.

The structure of the second chapter conceptually follows the original Summary Report but omits horizontal needs, whose funding is addressed through specific measures set out in the Action Plan of the National RDI Strategy 2030.[2] Selected horizontal needs from the Summary Report are addressed through measures for:

- **ensuring the improvement of the quality of human resources** are the selected sub-measures listed in section 2.1.1 Skills for research and innovation; 2.2.1. Quality research community; and 2.2.3 Lifelong learning;
- **providing solutions to the brain drain abroad** are defined by some of the sub-measures in section 2.2.2. Talent outflow and inflow
- **development and promotion of innovation in SMEs** are selected sub-measures in section 1.1.3. Researcher and innovator, not an accountant; 1.2.4. Open data and open science; 1.3.3 Reforms of competitive funding; 1.3.5 Funding for companies; 1.3.6 Funding from the European Union;
- **support for internationalisation**, some sub-measures have been specified in section 1.2.4. Open data and open science; 1.3.2 Institutional funding reforms; 1.3.4 Quality infrastructure; 1.3.6 European Union funding; 2.1.1 Skills for research and innovation; 2.2.1. Quality research community; 2.2.2 Talent outflow and inflow; and 3.1 Mission-driven approach;
- **completion, maintenance and development of infrastructure** are sub-measures of 1.3.4 Quality infrastructure;
- **protection of intellectual property rights** are sub-measures in section 1.2.3 Knowledge Linkages and selected sub-measures from section 1.3.2 Institutional Funding Reforms;
- **Funding** are the sub-measures from section 1.1.1 Consolidated governance; 1.1.2 Predictable inter-ministerial funding; 1.1.3 Connecting in the regions; 1.3.1 Increased budget; 1.3.2 Institutional funding reforms; 1.3.3 Competitive funding reforms; 1.3.5 Firm funding; 1.3.6 European Union funding;
- **legislation** are sub-measures of 1.1.1 Consolidated governance; 1.1.2 Predictable inter-ministerial funding; 1.2.1. Researcher and innovator, not an accountant; 1.2.2 Removing barriers; 1.2.3 Linking knowledge; 1.3.1 Increased budget; 1.3.2 Institutional funding reforms; 1.3.3 Competitive funding reforms; 1.3.5 Funding firms; 2.1.1 Skills for research and innovation; 2.2.2 Talent outflows and inflows; and 3.3 Value chains;
- **implementation of EU funds** are sub-measures 1.1.1. Consolidated management; 1.2.1. Researcher and innovator, not accountant; and 1.3.6 European Union funding.

Methodology for Updating the Summary Report of the EDP process to the Strategy SK RIS3 2021+

The preparation of the Smart Specialization Strategy is a highly interactive process that includes various links between stakeholders. EDP is the foundation for identifying priorities and transformational goals. It is not a one-off process, as it is intended to accompany the implementation of the SK RIS3 2021+ on an ongoing basis and to contribute to its completion/updating on a continuous basis.

EDP is a process that stems from cooperation with the business sector and its needs. It is not bound by a strict methodology with rigid rules and predefined procedures. Rather, it is a participatory process influenced by the engagement of the entrepreneurial environment, the current performance of research, development, and innovation (RDI), as well as by contextual and structural conditions in the regions.

[2] National RDI Strategy 2023 - Action Plan. Available at: https://vaia.gov.sk/wp-content/uploads/2023/03/Priloha_1_Akcny_plan_final.pdf

The aim of the EDP is to identify concrete, interconnected topics and the actors needed for their implementation— ones overlapping or contributing jointly to transformation in a priority area and that reinforce each other.

The expected outcome of the EDP is the identification of specific, actionable, and strategically complementary RDI thematic support areas that serve as the basis for defining calls and measures. These identified RDI support themes form the foundation for the preparation of calls, which - when developed in cooperation with the SK RIS3 2021+ domain working groups - constitute part of the continuous EDP. **In the previous Summary Report, these areas were represented by the so-called "transformational map", which, during the update process, was divided into three thematically interconnected parts:**

- **Current state of a priority area**
- **Thematic Support Area in a priority area**
- **Target state of a priority area**

The current state defines the initial information and database from which progress in the respective priority areas can be assessed. **The Thematic Support Area defines the thematic content of calls and the links between individual topics within a priority area**. It also serves as a thematic framework for investments and the related calls depending on resource availability (multi-source funding). **The Target state of a priority area specifies the intended impact** that RDI support in selected smart specialization areas should achieve. It is also a key prerequisite for properly designing calls in a way that ensures the RDI support themes contribute to pre-defined outcomes.

The interrelations **between thematic support areas and their associated transformational goals** are defined in a way that supports achieving the **target situation of a given priority area**. The identified support areas are complementary, and their mutual synergies should be encouraged. If the strategic complementarity among projects is managed effectively, it can initiate a lasting transformational process, eventually enabling the emergence of additional complementary projects.

Research and Innovation Strategy for Smart Specialization of the Slovak Republic 2021–2027 also **emphasizes addressing societal challenges through a multidisciplinary approach**. The identified priorities in each domain of the Summary Report represent proposed directions and concentration of available financial and human resources with the aim of maximizing economic benefits through research, development, and innovation while considering global trends and local potential. Without addressing current and expected societal challenges and their link to defined priorities, it is not possible to fully harness the RDI potential and achieve greater societal progress.

Considering the above, the **implementation of themes within domain priority areas will also support the field of social sciences**, which offers new and more effective tools to tackle societal challenges and involve a wide range of stakeholders in joint efforts to find complex solutions using new collaboration models. **In the context of societal challenges, the defined domains** create space for testing, validating, and measuring experimental solutions, as well as for establishing conditions for their systematic application. In addressing complex and multidisciplinary RDI projects within the priority areas of individual domains, and with the aim of maximizing transformational effects, complementary RDI activities in relevant social sciences and humanities will also be supported.

The EDP should be conducted across all engaged stakeholders and can take various forms, from spontaneous interdisciplinary brainstorming sessions to more formalized workshop settings.

An integral part of the priority areas in the Updated Summary Report are footnotes included directly within selected RDI support areas. These footnotes aim to clarify the interpretation of terms and to specify thematic

RDI support areas to prevent misinterpretation and ambiguity in the preparation of calls and in the implementation of projects.

Preconditions for defining/updating Priority Areas and Transformational goals[3]

- Priority areas must be clearly defined and appropriate for the given region.4
  - They must provide a framework for economic added value resulting from the strategy and structural improvements.
- Transformational objectives must be clearly defined and appropriately set.
  - They should not be too "general," but sufficiently specific and detailed (more than megatrends or generic "improvement").
  - They must be measurable; SMART indicators should be identified for the transformational objectives.
  - They should be ambitious, but not unattainable or unrealistic.
- Available capacities, potential data sources, and existing data and outcomes must be identified and evaluated.
- Priority areas and transformational goals must be accepted by stakeholders involved in the EDP.

Process of Updating Smart Specialization Domains in the Slovak Republic

The process of updating smart specialization domains began in 2023 in accordance with the SK RIS3 2021+[5], as part of the continuous EDP. In response to the need to ensure this process, a team of domain coordinators was established within the newly created unit at the Deputy Prime Minister's Office for the Recovery Plan and the Knowledge Economy (DPMO)[6]. An exception is Domain 3 - Digital Transformation of Slovakia, which is coordinated by the Ministry of Investment, Regional Development and Informatization of the Slovak Republic, in close cooperation with DPMO. Based on **domain platforms, Working Groups were established for each domain, led by a coordinator and visionaries, and in cooperation with the relevant competent ministries**. These groups consist of representatives from the business sector, the scientific and research base, academia, and the public/state administration, including representatives of associations and unions.

The activities carried out through a participatory approach, involving working groups in discussions on the update of each domain, led to the following changes in selected domains:

Domain 1: Innovative Industry for the 21st Century

Key Outcomes of the Domain Update:

- **Narrowing and refining of priority areas:** The domain update resulted in a reduction of the number of priority areas from 6 to 4, and the thematic RDI support areas were narrowed from 34 to 23. This rationalization enables more focused support for strategic priorities in the industrial sector.
- **Increased emphasis on digitalization and artificial intelligence:** The update process placed special emphasis on the integration of digitalization and artificial intelligence into selected priority areas. This

[3] The mentioned prerequisites will be applied within workshops, seminars, conferences, and popularization activities related to the EDP.
[4] In the context of the smart specialization strategy (RIS3), the term "region" is understood as a geographical area that has its own unique assets and resources. This area may be defined based on administrative boundaries, but it often focuses on specific socio-economic challenges and opportunities that are characteristic for the given region. Available at: https://ec.europa.eu/regional_policy/sources/policy/communities-and-networks/s3-community-of-practice/PolicyBrief_full_240419.pdf
[5] Page 100, Chapter 5.4. The process of continuous entrepreneurial discovery, SK RIS3 2021+ https://vaia.gov.sk/wp-content/uploads/2022/12/Strategia-vyskumu-a-inovacii-pre-inteligentnu-specializaciu.pdf
[6] Since January 1, 2024, the Research and Innovation Authority has been organizationally placed under the Deputy Prime Minister's Office for the Recovery Plan and the Knowledge Economy.

step reflects global trends and is key to improving the competitiveness of Slovak industry in international markets.

- **Linking to national and international strategic goals to support economic growth in Slovakia:** The update strengthened the alignment between the goals of the priority areas, the objectives of the National RDI Strategy 2030, and Slovakia's strategic objectives for enhancing economic competitiveness. Emphasis was placed on reflecting both national and international interests, which enhances synergies across sectors. Improved cross-sector and cross-ministerial cooperation - particularly in the areas of robotics, automation, raw material processing, and energy - strengthens Slovakia's position as an innovator and contributes to achieving global competitiveness.

Domain 2: Mobility for the 21st century

Key Outcomes of the Domain Update:

- **Reduction of priority areas:** The original three priority areas were reduced to two, with 12 thematic RDI support areas merged into 11. This simplification provides a clearer and more specific definition of activities aligned with the goals and milestones of the EU and Slovakia in the field of mobility.
- **Emphasis on multimodal transport cooperation:** The update emphasizes the development of railway, multimodal, and integrated transport systems, interoperability, and open data.
- **Description of the current and target state:** The current state is supported by relevant data, enabling more effective progress evaluation. These insights were also considered when defining the target state. Thematic areas are now focused on specific actions aimed at achieving set goals.
- **Consolidation of priorities in line with European objectives:** The update has aligned national priorities in transport and mobility with European strategic directions to support the development of smart, interconnected, and sustainable mobility.

Domain 3: Digital Transformation of Slovakia

Key Outcomes of the Domain Update:

- **Updated names and definitions of priority areas** in line with sectoral developments. Based on feedback from the working group, certain priority area names and definitions were updated to reflect developments in the sector. Emphasis was placed on the Internet of Things (IoT) and artificial intelligence (AI) systems. The existing structure and focus of the four priority areas were retained, as the working group considered them well defined.
- **Description of current and target states** supported by data and legislation. The description of the current and target states is grounded in data sources and legal frameworks, supporting fact-based decision-making. The target state was revised to better reflect the goals of each topic and to enable more effective goal monitoring.
- **Significant revision of inter-domain complementarities** at the thematic level: The updated domain reflects the growing cross-cutting importance of digital transformation across other domains. It was necessary to clarify the distinction between the integration of digital technologies within other domains and the development and innovation in digitalization as a stand-alone sector.

Domain 4: Healthy Society

Key Outcomes of the Domain Update:

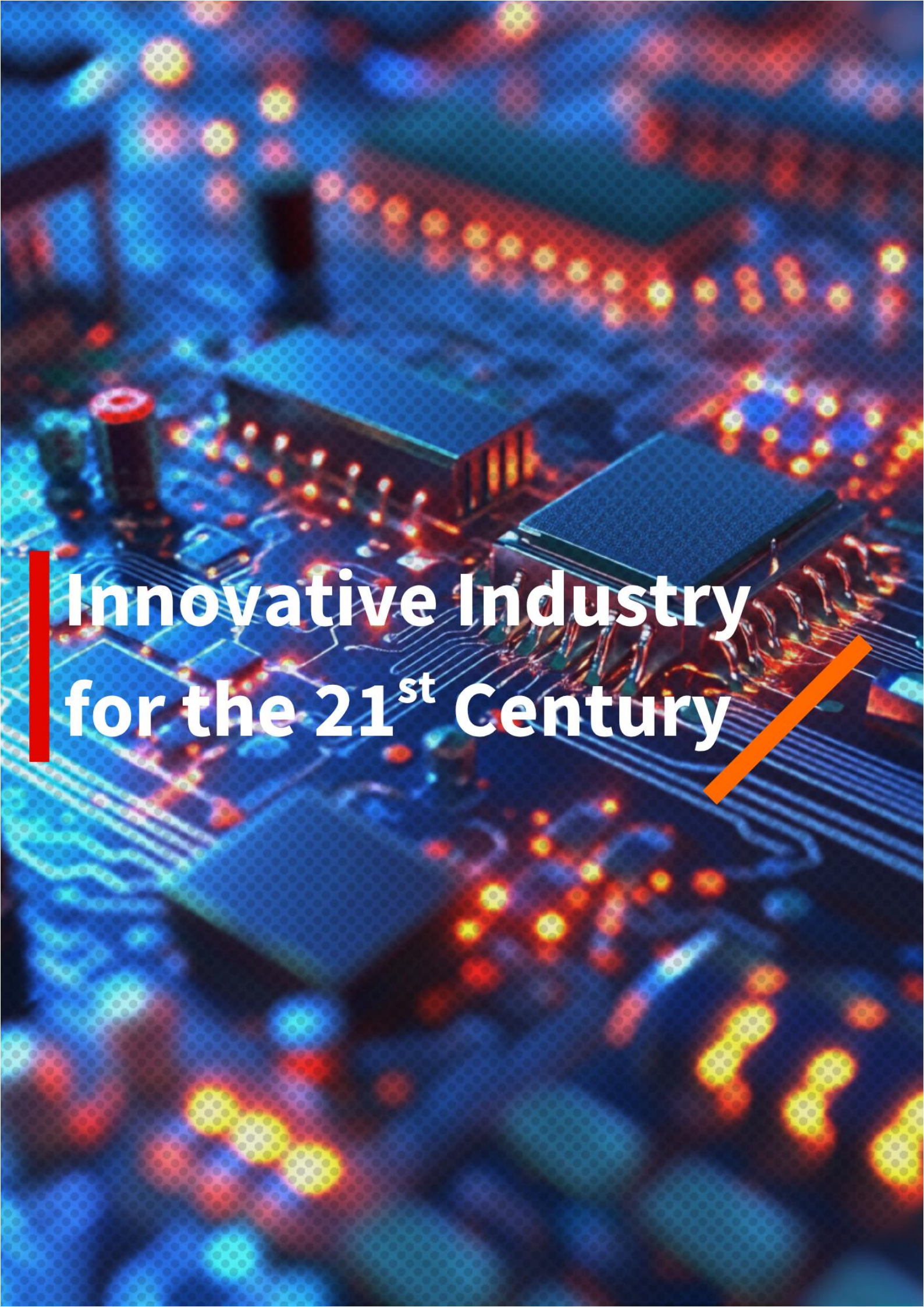
- **Redefinition and clarification of thematic RDI support areas:** The number of thematic support areas was updated to 17. This modification provides a clearer definition of the support areas, allowing for a more targeted focus of investments and activities in line with EU and SR priorities in the health sector.

- **Emphasis on global competitiveness and new technologies:** The update introduced content-based differentiation between priority areas, with a focus on expertise and trends in Slovak innovative applied research that demonstrates a clear global reach.
- **New thematic support areas were added to reflect current trends in healthcare technologies, particularly in the fields of prevention and screening.**

Domain 5: Food Competitiveness and Climate Resilience

Key Outcomes of the Domain Update:

- **Narrowing and redefinition of thematic RDI support areas:** The number of support areas was reduced from 54 to 6, with 3 new cross-cutting areas added. This streamlining contributed to a more precise definition of priorities in line with national and international goals related to food competitiveness and climate resilience.
- **Focus on key challenges and ecosystem support:** The update emphasized essential areas for supporting ecosystem development, also through a more rigorous database (comprehensive data analysis).
- **Rebranding the domain for greater clarity and more targeted impact of investments:** The new name of the domain - “Food Competitiveness and Climate Resilience” - reflects a shift toward priorities that are crucial for strengthening Slovakia’s innovation potential within this domain.


Innovative Industry
for the 21st Century

Smart Specialization Domains[7]

1. Innovative Industry for the 21st Century

The goal of the Innovative Industry for the 21st Century domain is:

- Transform the manufacturing character of Slovak industry into a manufacturing and-development industry with a high share of original innovations and R&D activities, leading to a significant increase in the added value of production and related services.
- Support the emergence of original innovations to ensure that the future position of Slovak manufacturers and suppliers in the supply chain is competitive and sustainable at the European level.
- Transform Slovak industry into an innovation-oriented sector with the perspective of creating and maintaining long-term jobs with a high share of creative (mentally satisfying) work, helping to reverse brain-drain.
- Increase the number of R&D staff and the share of their own innovations in companies, resulting in a more attractive portfolio of products with higher added value produced locally.
- Increase the added value of Slovak raw materials and semi-finished products by processing them into final products through material and technological innovations.
- Support innovative solutions and development in progressive technologies and materials applicable in industry and environmental protection.
- Increase the energy efficiency of industry, reduce environmental impacts, including further improvements of the energy mix towards carbon-neutral and low-carbon energy.
- Support the creation of original solutions leading to reduced negative environmental impacts of industry, increased energy efficiency, added value, and competitiveness.
- Support research, development, and implementation of progressive technologies and materials and breakthrough/new technologies in line with the European "Strategic Technologies for Europe Platform" (STEP) concept and the six strategic technologies for European technological sovereignty known as "Key Enabling Technologies" (KET).
- Support financing and participation of Slovak entities in co-funded international projects and European partnerships such as NATO DIANA and Horizon Europe.
- Increase sustainability, security, and resilience of Slovak industry. Support the circular economy, local production, efficient use of resources, and innovations that enhance the country's economic stability and security.
- Increase the resilience of all industrial sectors to disruptions in distribution systems and supply chains.
- Promote efficient use of public infrastructure by the private sector, effective utilization of shared infrastructure, and resolve conflicts related to state aid (shared infrastructure and innovation procurement) when using knowledge and infrastructure obtained from public sources.
- Support solutions in areas of public interest, particularly improving the quality of life of the population, environmental protection, and the resilience of state functioning in crisis situations.

[7] For each priority area of the domains defined by the EDP process, it is necessary during the implementation of activities that impact the collection, processing, and use of personal data to verify compliance with Regulation (EU) 2016/679 – Protection of natural persons with regard to the processing of personal data and on the free movement of such data. This assessment stems from point 11 of the List of processing operations subject to data protection impact assessment in the Slovak Republic, which states: 11. Processing operations using new or innovative technologies combined with at least one criterion specified in the WP 248 guidelines. Available at: https://dataprotection.gov.sk/uoou/sites/default/files/zoznam_spracovatelskych_operacii_ktore_podliehaju_posudeniu_vplyvu.pdf

1.1 Priority Area 1-1: Automation and Robotization of Production and Services

Transformational goal of the Priority Area 1-1

Transform industrial production to a high level of automation and robotization, support the integration of intelligent digital technologies into manufacturing processes during the transition to smart factories, as well as the implementation of hardware and software solutions for the automation needs of production and services. Create conditions for research, development, and the introduction of artificial intelligence in industrial processes.

Current state of the Priority Area 1-1

- There is broad expert consensus that automation and robotization are essential for maintaining the competitiveness of Slovak industry as well as strengthening its independence from the external environment. Besides **automation and robotization of industrial production, the development and deployment of technologies that include elements of artificial intelligence and handle large data sets are also necessary to increase competitiveness.**
- Research data from the Institute for Labour and Family Research in robotization and automation show that only 55.1% of companies (among those participating in the research) had implemented production automation; only 4 companies use big data, while digital technologies are most frequently used by companies (79.5%) in production activities. The research points out that one of the biggest barriers for companies introducing new digital technologies is the lack of adequately qualified employees.[8]
- Slovakia ranks among the leading countries in Central and Eastern Europe (CEE) with a **high share of enterprises using industrial** (6%) **and service** (3%) **robots**.[9]
- Both domestic and foreign analyses[10] indicate that one of the main problems in transforming Slovak industry is **insufficient support for research and development (R&D) in Slovakia**. Slovakia allocates only 0.93% of GDP to R&D (EU average is 2.26%). Such support is inadequate for **innovations in technological solutions** such as automation, robotization, artificial intelligence, and cloud systems implementation.
- Continuous modernization of industry requires investment. Innovation and R&D are financially demanding, and according to analyses, **total state-supported corporate research expenditures in Slovakia represent only 0.33% of GDP**, among the lowest in the European Union. Statistics show that **only 18% of small and medium enterprises invest in innovations**. Supporting research, development, and innovation (RDI) is an investment and a fundamental pillar for Slovakia to maintain product competitiveness in the market. [11]
- **Investments in artificial intelligence (AI) are the lowest** in Slovakia compared to V4 countries, despite having a similar starting position in 2015 compared to neighboring countries.
- Another negative indicator is the **decline in high-tech exports**, which has slightly decreased since 2017, with Slovakia again showing the lowest values in this statistic among V4 countries. Generally, a **higher percentage of high-tech exports indicates a country's ability to apply advanced technological innovations**.
- A significant problem is also the **lack of qualified workforce** in robotization, automation, and AI. Slovakia is among the top OECD countries with the highest share of jobs threatened by automation. [12]

[8] Institute for Labour and Family Research: Impact of Robotization, Automation, and Digitalization on the Labour Market in the Slovak Republic, Available at: https://ivpr.gov.sk/wp-content/uploads/2024/01/Vyskumna_sprava_digitalizacia.pdf
[9] Share of enterprises using robots in Central and Eastern Europe (CEE) in 2020, by country and type, Available at: https://www.statista.com/statistics/1282275/enterprise-usage-robots-share-among-enterprises-central-and-eastern-europe/
[10] Eurosotat-R&D expenditure. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=R%26D_expenditure&oldid=551418
[11] Dual Education Association - Industry 4.0, Available at: https://priemyselstyrinula.sk/viac-o-priemysle-4-0/
[12] European Commission - In Depth Review 2023 Slovakia, Available at: https://economy-finance.ec.europa.eu/system/files/2023-05/ip223_en.pdf

- Issues with the availability of qualified workforce for automation are related to a **skills mismatch with current technological development**. Slovakia is among the OECD countries with the highest degree of mismatch.[13] Reports from Eurostat, the European Commission, McKinsey Global Institute studies, PWC Slovak CEO Survey, and the Dual Education Association point to i**nsufficient skills and qualifications of employees in the process of implementing automation and robotization**. This problem concerns the **lack of university graduates in technical and natural sciences, which requires systemic solutions. Similarly, it is necessary to increase adult retraining and education**. The European Commission emphasizes the need for targeted state action in retraining employee skills.
- **The increased demand for technical** workers is also confirmed by data from CVTI SR and ÚPSVaR. According to these sources, the overall unemployment rate of university graduates in the field of "Technical sciences and doctrine" is 1.67%, which ranks this field as the second lowest unemployment rate. These claims are confirmed by data from Trends of Work[14] (a project implemented under the leadership of the Ministry of Labour, Social Affairs and Family of the Slovak Republic), where, **according to the results, graduates of secondary schools from the field of "Technical sciences and doctrines" earn on average the most among the other fields of study**. The results are similar for university graduates.

Thematic Support Area in the Priority Area 1-1

Innovative Industry for the 21st Century	
Priority Area 1-1: Automation and Robotization of Production and Services[15]	1.1.1. Research, development, and integration of hardware and/or software in the field of automation, robotic systems, and accessories
	1.1.2. Development and integration of solutions in production and internal logistics processes
	1.1.3. Research, development, and integration of measurement and monitoring systems for the needs of industry and other sectors
	1.1.4. Development and implementation of integration platforms

Target state of the Priority Area 1-1

- **A higher number of R&D personnel and a greater share of their own innovations in companies**. An increased number of R&D workers and employees with qualifications and skills aligned with the implementation of the Industry 4.0 concept will translate into a more attractive portfolio of products with higher added value produced locally.
- Industrial production operating on **highly automated and robotized intelligent systems** that integrate advanced robotic systems.
- **Development and integration of control systems for robotics and automation that support production efficiency and quality**, thereby enhancing the sustainability and competitiveness of local industry.
- Development and production of competitive products in the fields of digitalization, robotization, and automation with high export potential. **Creation and integration of new software and hardware solutions in service robotics.**
- **Creation and integration of new software and hardware solutions in industrial robotics**, including welding, logistics processes, and positioning and handling equipment.

[13] Commission Staff Working Document 2023 Slovakia, Available at: https://economy-finance.ec.europa.eu/system/files/2023-05/SK_SWD_2023_625_en.pdf
[14] Trends of Work: Graduates unemployment. Available at: https://www.trendyprace.sk/sk/absolventi/sk-trendy/nezamestnanost
[15] The solutions consist of automated machines, equipment, production lines, robots, and control procedures, with a high degree of reduction of human physical labor. Their goal is to increase the efficiency and effectiveness of operations in routine, monotonous, physically demanding, and health-straining activities, as well as in tasks requiring high precision.

- **A dynamic and integrated ecosystem established to support research, development, and implementation of innovative technologies** with overlap into the defense industry, ensuring mutually beneficial collaboration between public, private, and academic sectors. This strengthens national and regional security capacities, boosts the competitiveness of the European defense industry, and ensures a sustainable and effective approach to modernizing defense systems and technologies.
- Innovations are also created in local research centers and companies, ensuring that the added value remains within the Slovak economy and contributes to its growth and global competitiveness.
- **A higher share of local suppliers in subcontracting** (components, sensors, software, automated systems) for digitalization and automation of industry. Solutions and innovations developed find applications in sectors such as healthcare, agriculture, food industry, and transport, thereby increasing the resilience of these sectors.
- **Increased competitiveness, sustainability, and resilience of Slovak industry**. Support for local production and innovations enhances the stability and security of the country.
- Developed and deployed **integrated platforms** that unify various hardware and software solutions in service robotics, robotic technologies, and automation and robotization of industrial and logistics processes.
- **A greater number of platforms supporting both internal and external integration requirements and enabling flexible and efficient collaboration** between different systems and sectors. This strengthens the development of smart manufacturing enterprises and warehouses. Their existence increases overall productivity and efficiency of logistics and production and supports regional development and cooperation among local companies.

1.2 Priority Area 1-2: Processing of Raw Materials and Semi-Finished Products into Higher Added Value Products

Transformational goal of the Priority Area 1-2

Increase the added value of exported raw materials and semi-finished products by processing them into final products with higher added value.

Current state of the Priority Area 1-2

- Our economy still has significant **potential for more efficient and valuable processing of exported raw materials and semi-finished products into higher value-added products**. This mainly concerns commodities such as wood, aluminum alloys and profiles, steel semi-finished products, cellulose, etc.
- Given Slovakia's energy mix dominated by stable supply of emission-free nuclear electricity, decreasing energy intensity of the economy, and the continuing and planned construction of new nuclear blocks, **Slovakia has the potential to become a net exporter of electrical energy**. As an alternative to exporting only electricity, it is desirable to **export products into which electrical energy is embedded**, thus creating synergistic effects together with the use of domestic raw materials and energy resources, resulting in higher added value.
- Slovak production of aluminum and steel is under pressure from rising energy prices and commitments to reduce greenhouse gas emissions. To strengthen competitiveness, including possible restarting of aluminum production, investments in modernization of production technologies, optimization of recycling processes, increased share of renewable sources, and **increased R&D investments in research centers focusing on metallurgy are essential.**
- Processing of wood raw materials into higher value-added products is insufficient in Slovakia, as are capacities and technologies that could contribute to higher added value. A problem also lies in the linkage between primary and secondary wood processing in the production chain, with **significant export volumes in the form of lumber (up to 66% in 2022)**, which gains higher added value only during subsequent processing abroad.

- Compared to EU countries, Slovakia **lacks excellent research facilities, and the number of scientists and graduates in relevant fields is low**[16] (approximately 180 per year).
- The growing demand for the use of primary resources is significantly worsening the EU's material self-sufficiency and increasing pressure on the environment. EU recycling rates for waste (municipal, packaging and e-waste) are increasing. The highest recycling rates in 2021 were for packaging (65.4%) municipal waste (49.5%) and e-waste recycling (90.9%)[17] **In Slovakia, recycling and use of secondary raw materials is gradually improving, but there remain significant gaps** compared to other EU countries such as Germany, Austria, Slovenia, or the Netherlands. In municipal waste recycling, Slovakia slightly exceeds the EU27 average (49.5% in Slovakia, 48.7% EU27 average).
- A major shortcoming limiting Slovakia's ability to increase waste processing and use of secondary raw materials is the **lack of recycling capacities**, especially for plastics, [18] metals,[19] and other materials that represent a significant share of total waste in Slovakia (wood, paper and cardboard, glass, textiles, tires, construction waste, etc.).
- According to EU goals and initiatives, the share of secondary raw materials in the economy is expected to increase in the coming years. For Slovakia, this means the **need for further development and innovations in recycling and use of secondary raw materials**, which will be key for achieving a sustainable economy and meeting environmental targets.
- **Slovakia's energy recovery from municipal waste is low, and the heat generated is insufficiently used in district heating systems.** In 2022, only 7.8% of non-recyclable waste was recovered, compared to the European average of 26%.[20]

Thematic Support Area in the Priority Area 1-2

Innovative Industry for the 21st Century	
Priority Area 1-2: Processing of Raw Materials and Semi-Finished Products into Higher Added Value Products	1.2.1. Support for innovative technologies for processing aluminum into products with higher added value
	1.2.2. Innovative steel and iron alloy products, material and technological innovations aimed at greater use of local semi-finished products in industrial production and other sectors
	1.2.3. Processing of wood raw materials into higher value-added products
	1.2.4. Processing of cellulose into higher value-added products
	1.2.5. Separated secondary raw material products

Target state of the Priority Area 1-2

- **Integrated and sustainable production systems** that maximize the use of local raw materials and technologies.
- **Development and implementation of advanced processing technologies** across various industrial sectors, resulting in higher added value and efficiency.
- **Increased added value of raw materials and semi-finished products through material and technological innovations.**

[16] Eurostat-R&D personnel. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=R%26D_personnel&oldid=624836
[17] Eurostat. Available at: https://ec.europa.eu/eurostat/databrowser/explore/all/tb_eu?lang=en&subtheme=cei.cei_wm&display=list&sort=category&extractionId=cei_wm060
[18] Since January 1, 2023, the obligations related to the extended responsibility of producers of specific plastic products have been expanded. Available at: https://environment.ec.europa.eu/publications/proposal-revised-urban-wastewater-treatment-directive_en
[19] In 2021, the volume of metal waste produced (in tons) in Slovakia reached its highest increase since 2016 (an increase of 36%). Available at: https://www.zopsr.sk/wp-content/uploads/2023/05/BIELA-KNIHA-OH-V-SR_JUL_2023.pdf
[20] https://www.cewep.eu/wp-content/uploads/2023/09/EU-Waste-treatment-2021.pdf

- **Strengthened local economy and improved position of Slovak industry in the global market.**
- In the areas of wood and cellulose production and processing, manufacture of innovative products with higher added value, with emphasis on ecological and sustainable practices.
- **Improved linkages between research, development, and production** enhance the competitiveness of Slovak industry and contribute to environmental sustainability.

1.3 Priority Area 1-3: Progressive Technologies and Materials

Transformational goal of the Priority Area 1-3

Intensive research, development, and implementation of innovative technologies and materials that bring innovative solutions with high potential positive impact on society in promising areas needed for sustainable economic development, while simultaneously supporting the growth of export opportunities.

Current state of the Priority Area 1-3

- **Research and development in technologies** defined **under priority area 1-3 are currently conducted at a limited scale in Slovakia.**
- The context of research and development in progressive technologies significantly affects Slovakia's ranking in the European Innovation Scoreboard, where **Slovakia scored 65.1 points** (i.e., 65.1% of the EU countries' average performance), placing it among the so-called "Emerging Innovators." These are countries with emerging innovation potential but with a performance level less than 70% of the EU average. Between 2014 and 2019, Slovakia was among the EU countries that increased innovation performance, but the EU average grew twice as fast, and this trend continues today. This indicates considerable room for improvement and development in innovation.[21]
- **In the area of progressive technologies, environmental protection, and use of renewable energy sources**, Slovakia scored 87.1 points in the 2024 European Innovation Scoreboard. **This area saw the most significant decline among all EIS indicators for Slovakia**, with a drop of 52.3 points between 2017 and 2024. [22]
- Priority of **Progressive Technologies and Materials intersects with strategic areas supported by EU** instruments under the "Strategic Technologies for Europe Platform (STEP)" [23] concept and the six strategic technologies for European technological sovereignty within the "Key Enabling Technologies." [24]
- **Slovakia, based on the above indicator, consistently lags the EU average year-over-year and is among countries with relatively low innovation shares in biotechnology**. With a score of 31.1 points on the Global Biotechnology Innovation Scoreboard, Slovakia ranks 34th out of 54 countries. [25]
- **According to the Eco-Innovation Index, which monitors ecological innovation performance** in EU countries, **Slovakia has improved in efficient resource use and reduction of environmental pressures**, placing it in the "Eco-Innovation Catching-up" group. [26]
- There is a **lack of effective cooperation between the public sector and industry in research and development. Innovative original solutions created in Slovakia with real-world applications are rare**. In statistics measuring university-industry collaboration in research and development, Slovakia ranks 101st.

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[21] European Commission: European Innovation Scoreboard 2024. Available at: https://op.europa.eu/en/publication-detail/-/publication/8a4a4a1f-3e68-11ef-ab8f-01aa75ed71a1/language-en
[22] European Commission: European Innovation Scoreboard 2024: Country profile Slovakia. Available at: https://op.europa.eu/en/publication-detail/-/publication/8a4a4a1f-3e68-11ef-ab8f-01aa75ed71a1/language-en
[23] European Union: Strategic Technologies for Europe Platform: Targeted investment areas. Available at: https://strategic-technologies.europa.eu/about/targeted-investment-areas_en
[24] Study: European Parliamentary Research Service. Available at: https://www.europarl.europa.eu/RegData/etudes/STUD/2021/697184/EPRS_STU(2021)697184_EN.pdf
[25] thinkBiotech: Global Biotechnology Innovation Scorecard. Available at: https://www.thinkbiotech.com/globalbiotech/country/Slovak+Republic
[26] European Union: Eco-Innovation Scoreboard. Available at: https://green-business.ec.europa.eu/eco-innovation_en

Thematic Support Area in the Priority Area 1-3

Innovative Industry for the 21st Century	
Priority Area 1-3: Progressive Technologies and Materials[27]	1.3.1. Research and development of nanomaterials for various industrial sectors – progressive materials
	1.3.2. Research and development of progressive technologies in environmental protection and renewable energy use
	1.3.3. Technological innovations in production processes related to waste recycling, waste reduction, and minimizing negative environmental impacts
	1.3.4. Research and development of biotechnologies and (bio)materials
	1.3.5. Research and development of new types of smart materials for energy conversion, transport, and storage
	1.3.6. Research and development of breakthrough/completely new technologies

Target state of the Priority Area 1-3

- **Development and deployment of solutions in progressive technologies and materials, for example through modern digital technologies, including artificial intelligence.**
- **Innovative solutions and development in progressive technologies and materials** applied in industry, regarding environmental protection and saving primary raw material savings.
- Nanomaterials and biomaterials for various industrial sectors, progressive technologies for environmental protection and renewable energy use, and smart materials for energy conversion, transport, and storage **increase production added value, reduce environmental burden, and improve employees' social conditions**.
- **Effective know-how transfer through innovative technological and non-technological solutions into practice**, including licensing, and increased financial revenues from the sale of intellectual property rights.
- **Increased interest and strengthened protection of intellectual property** of companies in Slovakia through a higher number of patents and utility models.
- **Emergence of technology companies (micro-startups/spin-offs, small, medium, and large) and retention of young talents** in Slovakia.
- Higher number of startups receiving increased support and improved access to venture capital.
- **Physical and virtual spaces for young creative people** who will not emigrate abroad.
- **Biotechnologies and biomaterials leading to innovative and commercializable solutions.**

1.4 Priority Area 1-4: Energy Security, Efficiency, and Sustainability

Transformational goal of the Priority Area 1-4

Achieve significant progress towards increasing energy security, efficiency, and sustainability while further enhancing the competitiveness of industry. This includes, among other things, further reducing dependence on fossil fuels, extending the lifespan of existing nuclear reactors, improving the nuclear fuel cycle, increasing the flexibility, capacity, and stability of transmission grids and networks. Improve the efficiency of waste

[27] Means technologies and materials of the first grade and of a higher technological standard than the standard of current technology and materials of the same type.

energy use in the form of heat and electricity, for example through research and development of systems for their effective storage, transfer, and use, as well as reducing the total amount of produced waste energy.

Current state of the Priority Area 1-4

- **According to the latest available data (2022), industry is the largest energy consumer sector (41.4%).** It is also the biggest consumer in final energy consumption of gas (31.5%), coal (88.1%),[28] and the second-largest consumer of oil after transportation.[29] A large portion of energy consumed by industry is imported. **The insufficient diversification of imported energy raw materials is a problem that is being gradually addressed.**
- **The largest shares of energy consumption in industry** are **iron and steel production** (17.3%), **engineering** (14.6%), **non-ferrous metallurgy** (12.8%), **manufacturing of transport equipment** (11.1%), **pulp**, **paper and printing** (9.39%), and **chemistry** (7.22%).[30]
- **The Slovak energy system (electricity and heat production) relies heavily on nuclear power**, which accounts for 78.4% of total electricity produced (GWh), and heat production from fossil fuels (GWh) generated in public heating plants and heat stations, which account for 93.1% of total heat production in Slovakia.[31] High fossil fuel consumption in the energy mix results in high emissions.
- **The stability of zero-emission electricity supply is ensured by the safe operation** of five fully functional nuclear reactors with a planned lifespan of 60 years. Possible commercial operation beyond this limit is under investigation.
- Slovakia has high energy-intensive economy and, at the same time, considerable **energy losses mainly due to the production of unused heat**, which is released into the atmosphere without benefit, thus offering potential for energy recovery.
- **Market price instability** (extreme fluctuations over the last 3 years) and higher compensation fees (emission allowances) significantly worsen the competitiveness of Slovak industry, with serious economic and social consequences for the country.
- **Ensuring the stability of the Slovak energy system** depends on the **flexibility of the electric grid**. Flexibility plays a crucial role in maintaining system balance **and increasing resilience to extreme changes**. Slovakia, Hungary, and Austria remain countries where grid stability depends on gas supplies.
- The Ministry of Economy of Slovakia has set a commitment to increase storage capacity by 2026, mainly through battery storage, hydrogen, and pumped-storage stations. Battery storage is among the fastest deployable commercial energy storage technologies.
- Selected technologies defined in this priority area – support for research of intelligent and autonomous grids, new methods of storing unused energy, nuclear research support, devices and technologies for waste heat recovery, devices and technologies for energy recovery from waste – **intersect with EU strategic areas supported under the** "Strategic Technologies for Europe Platform (STEP)".[32]
- The construction sector and buildings in EU countries currently face major challenges related to climate change and the EU's ambitions to transform the sector to be energy neutral. 85% of buildings in the EU were built before 2000, and 75% of them have low energy efficiency.[33] **Technologies that improve the energy efficiency** of buildings are key to saving energy, reducing household and business costs, and contributing to decarbonization targets by 2050.

[28] Statistical Office of the Slovak Republic: Energy 2022 - Balances of fuels, electricity, and heat for the year 2022. Available at: https://slovak.statistics.sk/PortalTraffic/fileServlet?Dokument=b23c3b09-d5bb-482d-bb58-9a5392b026fe
[29] Analysts of ÚMS: Analytical Commentary - Small Energy Overview, National Bank of Slovakia. Available at: https://nbs.sk/dokument/15544e56-c940-498c-93eb-30181d29c5b9/stiahnut?force=false
[30] Office of the Slovak Republic: Energy 2022 - Sources and consumption of electricity and heat for the year 2022. Available at: https://slovak.statistics.sk/PortalTraffic/fileServlet?Dokument=b23c3b09-d5bb-482d-bb58-9a5392b026fe
[31] Statistical Office of the Slovak Republic: Energy 2022 - Sources and consumption of electricity and heat for the year 2022. Available at: https://slovak.statistics.sk/PortalTraffic/fileServlet?Dokument=b23c3b09-d5bb-482d-bb58-9a5392b026fe
[32] European Union: Strategic Technologies for Europe Platform: Targeted investment areas. Available at: https://strategic-technologies.europa.eu/about/targeted-investment-areas_en
[33] European Commission: Energy - Energy Performance of Buildings Directive. Available at: https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en

- **An important regulatory tool accelerating the deployment of new technologies for increasing energy efficiency** in buildings in the EU is the "**Energy Performance of Buildings Directive**,"[34] whose updated text was approved by the European Parliament in March 2024. The directive defines two main goals for EU member states: 1) new public sector buildings or buildings owned by public entities must have zero emissions by 2028; 2) all new buildings must have zero emissions by 2030.
- According to Statistical Office data for 2022, **Slovakia currently utilizes a low degree of energy recovery from municipal waste** – only 7.8% of the total waste volume (in tons).[35] **Slovakia's rate of municipal waste recycling in Europe is slightly above the EU average** (48.9% in Slovakia vs. 48.73% EU average).[36] **By 2035**, **an increase in unrecyclable municipal waste** (mixed municipal waste) and bulky waste **is expected** in Slovakia to about 1.1 million tons. Industrial waste increase could be approximately 0.15 million tons. This increase in municipal waste volume represents a suitable resource for energy recovery, for which current processing and technological capacities are insufficient.[37]

Thematic Support Area in the Priority Area 1-4

Innovative Industry for the 21st Century	
Priority Area 1-4: Energy Security[38], Efficiency[39], and Sustainability[40]	1.4.1. Research, development, and implementation of energy efficiency measures
	1.4.2. Research, development, and implementation of devices and technologies for capturing or utilizing waste heat
	1.4.3. Research, development, and implementation of technologies and devices for efficient heating and cooling
	1.4.4. Research, development, and implementation of devices and technologies for the energy recovery of waste
	1.4.5. Research and development in the field of nuclear energy
	1.4.6. Research, development, and implementation of new methods for storing unused energy
	1.4.7. Research, development, and implementation of intelligent and autonomous networks

Target state of the Priority Area 1-4

- **The competitiveness of industry is increased** through innovations in energy security, efficiency, and sustainability.
- **Innovative technologies, products, services, and processes with high added value** are used to reduce energy demands.

[34] EUR-Lex: Directive of the European Parliament and of the Council (EU) 2024/1275 of 24 April 2024 on the energy performance of buildings (recast) (Text with EEA relevance). Available at: https://eur-lex.europa.eu/legal-content/SK/TXT/?uri=CELEX:32024L1275
[35] Statistical Office of the Slovak Republic – Waste in the Slovak Republic for the year 2022: Amount of municipal waste in the Slovak Republic by method of management in tons 2010 – 2022. Available at: https://slovak.statistics.sk/PortalTraffic/fileServlet?Dokument=b8a5ccec-21ac-4bf4-8bc3-b9947ec2b7bc
[36] European Environment Agency: Municipal waste recycling rates in Europe by country. Available at: https://www.eea.europa.eu/data-and-maps/daviz/municipal-waste-recycled-and-composted-7#tab-chart_7
[37] Waste Industry Association: White Paper on Waste Management in the Slovak Republic. Available at: https://www.zopsr.sk/wp-content/uploads/2023/05/BIELA-KNIHA-OH-V-SR_JUL_2023.pdf
[38] Availability of necessary energy at any time in various forms, in sufficient quantities and at affordable prices, without unacceptable or irreversible impact on the environment.
[39] Refers to the ability to achieve the best results in any given activity using the least possible amount of energy resources, with the aim of reducing energy waste and minimizing resource consumption, thereby achieving cost savings, reducing environmental burden, and improving overall sustainability.
[40] Obtaining energy from sources that can meet current needs without compromising future energy needs or future generations.

- **Increased energy efficiency reduced environmental impact, and further improvement of the energy mix towards carbon-neutral and low-carbon energy.**
- **Innovative technologies and devices for further utilization of waste heat**, including low-potential heat.
- **Stability of the energy system** is ensured by increased energy storage capacity (primarily electrical energy) and intelligent and autonomous network management for more efficient control and distribution of energy while maintaining cybersecurity.
- **Unused electrical energy is stored using innovative and new methods** such as electric accumulators, capacitors, efficient hydrogen production, energy-intensive products, and production of alternative fuels using surplus energy.
- **Innovative technologies are used for efficient cooling and heating** of buildings with low-potential heat and heat recovery.
- **Innovative technologies are used for efficient cooling and heating** buildings with low-potential heat recovery.
- **Renewed and continuous research in nuclear energy**, including safety improvements and integration of advanced technologies, extending the lifespan of existing nuclear facilities, reuse of spent fuel, safe management and storage of nuclear waste, decarbonization, and support of international cooperation.
- **Diversification of primary energy sources.**

Table 1: Essential Prerequisites for the Implementation of the Domain Innovative Industry for the 21st

Title of Prerequisite	Description of Prerequisite
Support for Subcontracting Chains	Support for subcontracting relationships with the aim of increasing the volume of locally processed raw materials or semi-finished products into higher value-added products in Slovakia (respecting state aid scheme limits and potential price dumping).
Support for Research and Technological Solutions Enabling Optimal Use or Storage of Surplus Energy Produced in Industry	Support for energy interconnection of industrial facilities with the surrounding community environment to optimize the use or storage of surplus energy produced or usable in both sectors.
Maintenance of Competence for Nuclear Safety and Decommissioning of Nuclear Energy Sources	Adoption of a national strategy to ensure and maintain competence in nuclear safety.
Ensuring Continuous Funding for Energy Research	Energy is part of Slovakia's critical infrastructure, and it is the government's responsibility to support research and human resources in low-carbon technologies and clean energy technologies.


Mobility for the
21st Century

2. Mobility for the 21st Century

The goal of the Mobility for the 21st Century is:

- Support economic development and technological progress across all modes of transport.
- Improve the performance assessment of the system and specific actors in this domain.
- Increase safety and user comfort for all transport users.
- Ensure protection of transport infrastructure through rules and principles for its use, implementing automated systems (e.g., speed, weight, and vehicle dimension control, and infrastructure diagnostics).
- Enhance user experience, accessibility, and utilization of digital services in the field of mobility and intelligent transport and logistics systems.
- Increase the share of goods and people transported using multimodal and integrated approaches and innovative solutions in transport, including innovative business models.
- Reduce the negative environmental impacts of transport through RDI.
- Support new connections between industry and service providers with RDI organizations and relevant public sector actors in functional multilateral collaborations.
- Improve coordination and streamline the use of public investments in RDI infrastructure.
- Enhance the quality and availability of human resources for RDI in this domain.
- Network the RDI ecosystem more effectively at the level of research teams, projects, and institutions in this domain.
- Consider the cross-cutting nature of mobility issues and support the implementation of complex and interdisciplinary research projects that provide solutions to improve accessibility and availability of transport needs fulfillment for specific territories and population groups.
- Enable the development of complex interdisciplinary solutions using interconnected knowledge from STEM (Science, Technology, Engineering, and Mathematics), biomedical sciences (e.g., relating to passengers or traffic participants), economics, and social sciences through RDI projects in this domain.
- Increase cooperation between the private and public sectors, as well as within the private sector itself, and participation in joint and European projects in the field of intelligent, connected, and sustainable mobility.
- Increase the share of research and development activities of universities and scientific centers conducted in collaboration with industry (e.g., contract research) to support Slovakia's international competitiveness.[41]
- Support research, development, and implementation of technologies defined in the STEP (Strategic Technologies for Europe Platform) and aligned with the objectives of this domain.
- Establish a technological plan for innovation and implementation strategy, as well as a regulatory framework for intelligent mobility, to effectively connect European and domestic research and innovation policies in the field of mobility and logistics.

[41] Ministry of Finance of the Slovak Republic: Review of Expenditures, Competencies, and Personnel Capacities in Research, Development, and Innovation. Available at: https://vaia.gov.sk/wp-content/uploads/2023/10/04_Priloha_Revizia-vydavkov-kompetencii-a-personalnych-kapacit-vo-vyskume-vyvoji-a-inovaciach.pdf

2.1 Priority Area 2-1: Intelligent Mobility

Transformational goal of the Priority Area 2-1

Support research and development of technologies and innovative solutions for the deployment of connected, automated, and autonomous vehicles and systems to increase safety, smoothness, and efficiency of transport.

Current state of the Priority Area 2-1

- **Current legislation allows trial operation of automated and fully automated vehicles** within a designated time, area, or route, provided the conditions for operation permission are met and approved by the relevant authority. It also establishes conditions for permitting the operation of automated delivery vehicles. [42]

- **Legislation and regulations do not yet reflect the need for data sharing** generated by intelligent mobility systems or the functioning of new business models.

- **The environment for connected vehicles depends on telecommunication network connectivity, with potential risks of cyberattacks on these systems**. The current setup of information systems **is insufficiently protected by information and cybersecurity measures**, which, depending on the development stage of intelligent vehicles, increases safety risks.[43]

- **The existing research and development base** in Slovakia **is mainly defined by laboratory workplaces in academic institutions and a limited number of standalone workplaces** in corporate technology/research centers. **A combined R&D and testing infrastructure,** like foreign institutions **that integrate labs and testing tracks and meet the requirements for testing intelligent and autonomous mobility elements, is completely lacking in Slovakia.**[44]

- **The prospect of faster deployment of autonomous vehicles is generally limited by low public awareness of the benefits of this mode of transport** and perceived **safety concerns** regarding the introduction of autonomous vehicles into road traffic.[45]

- **A significant issue** affecting the development of autonomous and automated transport in Slovakia **is the quality of physical road infrastructure** (Slovakia's investments in road infrastructure development are at 109% of the EU average, weighted by investment per length of infrastructure), **the quality of railway infrastructure** (Slovakia's investments in railway infrastructure development are at 21% of the EU average, weighted by investment per length of infrastructure)[46], as well as the absence of digital versions and passports of infrastructure and transport systems, and insufficient coverage by **5G broadband**

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[42] Act No. 429/2022 Coll., amending and supplementing certain laws related to the development of automated vehicles, effective from 02.01.2023. Available at: https://www.slov-lex.sk/pravne-predpisy/SK/ZZ/2022/429/

[43] ANDRAŠKO, J. et al. Legal and Technical Aspects of Cybersecurity of Automated Vehicles. 1st edition. Bratislava: Wolters Kluwer SR s. r. o., 2022, 160 p.

[44] Verification of the technical feasibility of the future research and development testing environment for road transport for intelligent mobility in the Slovak Republic, Final Report. 2023.

[45] Transportation Research Part F: Traffic Psychology and Behavior. Available at: https://www.sciencedirect.com/journal/transportation-research-part-f-traffic-psychology-and-behaviour

[46] To calculate Slovakia's position regarding infrastructure investments compared to the EU-27, CH, NO, and UK, data from Eurostat datasets (rail_if_line_ga, road_if_motorwa, road_if_roadsc) and OECD (ITF (2024), "Transport infrastructure investment and maintenance", ITF Transport Statistics (database), https://doi.org/10.1787/g2g55573-en (accessed on 22 October 2024)) were used. Subsequently, the data were cleaned by removing countries with missing data, namely BE, DE, EL, MT, and PT. From the average values over the period 2013-2022, a weighted average of investments per kilometer of infrastructure was calculated, based on which the comparison was made.

networks (Slovakia – 14% of populated areas / EU – 66% of populated areas)[47]. For testing, development, and communication of autonomous vehicles with their surroundings and each other (including railway transport), a standalone 5G (SA) network is required.

- Currently, the **provision of transport services is isolated due to an insufficient number of infrastructure nodes and lack of information** for coordination and chaining of their use, including mode changes. Carrying out such transportation **requires considerable effort from passengers and users of transport services**, which reduces comfort and consequently the demand for such services.

- Slovakia ranks **4th among EU countries in Europe in terms of total passenger car production in the EU**[48] (1st DE; 2nd ES; 3rd CZ; 4th SK; 5th FR). **Between 2020 and 2023**, Slovakia's **production of passenger cars increased by 11.2%** despite the impacts of COVID-19 (supply chain issues), the energy crisis, and other significant consequences related to the geopolitical situation worldwide. Despite Slovakia's significant position in car production, **it lags in automotive R&D**, closely related to the insufficient establishment of R&D capacities of final manufacturers and suppliers in the Slovak automotive industry.

- According to UN trade statistics, **Slovakia is among EU countries that have a significant positive impact on the foreign trade balance in the export of railway vehicles and equipment**.[49] Thanks to the structure of its industry and export orientation, **Slovakia has the potential for further expansion of production capacities in railway transport supplies**.

- **Increasing the level of automation** and **supporting the digitization of railway transport are long-neglected areas in Slovakia**. With the current length of the Slovak Railways network **(ŽSR) at 3,580 km, only 12% of all operated lines are remotely controlled (centers with regional delimitation)**. In 2023, ŽSR invested only €98,000 in automating railway traffic control, although according to the 2019 ŽSR central traffic control project proposal, implementation could reduce the number of employees needed for railway traffic management by up to 50%. R&D in digitalization and automation of railways indicates a 10-15% increase in railway efficiency due to capacity increases, smoother train operations, improved scheduling and circulation of wagons and locomotives, including a 10-20% reduction in energy consumption.[50]

- **In the field of railway R&D, Slovakia lacks participation in European partnership projects, such as Europe's Rail Joint Undertaking.**

- According to the study titled "Verification of the technical feasibility of the future R&D testing environment for road transport for intelligent mobility in the Slovak Republic," **in 2023, 22 companies were involved in intelligent mobility in Slovakia, including 9 SMEs and 13 large enterprises, with a total of 755 employees.**

[47] Digital Economy and Society Index 2022 - Slovakia. Available at: https://digital-strategy.ec.europa.eu/sk/policies/desi
[48] Economic and Market Report-Global and EU auto industry 2020/2023. Available at: https://www.acea.auto/publication/economic-and-market-report-global-and-eu-auto-industry-full-year-2023/
[49] European Parliament: Perspectives for the rolling stock supply in the EU. Available at: https://www.europarl.europa.eu/RegData/etudes/STUD/2023/747263/IPOL_STU(2023)747263_EN.pdf
[50] Rail Freight Forward: Green Deal Paper. Available at: https://www.railfreightforward.eu/sites/default/files/downloadcenter/200710_green_deal_paper_rff_final_2020070712h00.pdf

Thematic Support Area in the Priority Area 2-1

Mobility for the 21st Century	
Priority Area 2-1: Intelligent Mobility	2.1.1. Integration of connected and automated systems and vehicles in relevant areas of society
	2.1.2. Research and development base [51] with industry participation for various modes of collaborative, connected, and automated mobility
	2.1.3. Pilot testing of new technologies and services with emphasis on multimodality
	2.1.4. Development of tools for real and virtual testing of connected, autonomous, and automated vehicles
	2.1.5. Development and implementation of dynamic traffic and logistics management systems
	2.1.6. Integration of intelligent management with a focus on the interoperability of transport systems

Target state of the Priority Area 2-1

- **An environment enabling the use of connected, automated, and autonomous vehicles** in regular operation (not only in testing conditions).
- **Establishment of testing and R&D infrastructure covering a broad spectrum of intelligent mobility areas**, including traffic flows and management, intelligent transport infrastructure, robotic, automated, and autonomous transport, safety, and new types of drives and technologies.[52]
- **Increased public awareness of autonomous transport safety** and its acceptance.
- **Integration of connected, automated, and autonomous vehicles, technologies, and systems in transport.**
- **Integration of systems and technologies for intelligent maintenance of infrastructure and vehicles**, enabling failure prediction and maintenance optimization based on data analysis and simulations.
- **Integration of automated systems for traffic rule enforcement** across all transport modes (speed limits, permissible dimensions and load).
- **Growth in the number (or size) of companies** focused on intelligent mobility technologies, systems, and services with potential for international competitiveness in this sector.
- **Higher number of R&D staff** with expertise in connected and autonomous mobility, advanced sensors, and perception systems, and **increased participation of Slovakia in international projects under European schemes** such as Horizon 2020,[53] Horizon Europe, and successor framework programs after 2027.

[51] Research and development base includes infrastructure and human capacities.
[52] Feasibility study of the future research and development testing environment for road transport for intelligent mobility in the Slovak Republic, Final report. 2023.
[53] During the entire programming period of the European Horizon 2020 scheme, research institutions and companies from the Slovak Republic received a total allocation of EUR 3,568,561 in projects in the field of mobility (including funds from connected and autonomous mobility). Available at: https://dashboard.tech.ec.europa.eu/qs_digit_dashboard_mt/public/sense/app/d58f3864-d519-4f9f-855e-c34f9860acdd/sheet/KVdtQ/state/analysis

- **Legislative and regulatory environment that reflects the need for data sharing** generated by intelligent mobility systems, enabling new business models and protecting the ecosystem through cybersecurity solutions.

- **Legislative and regulatory framework facilitating efficient approval and authorization** of deployment of intelligent mobility technologies, systems, and services.

- **Increased use of services and innovative business models in public transport and logistics, and improved user experience (e.g., through connecting systems and availability of information** such as traffic flows, vehicle and infrastructure capacities, vehicle categorization).

- **Increased accessibility and improved use of open data and data spaces** in intelligent mobility from publicly funded projects regardless of funding source (EU funds, Recovery and Resilience Plan, state budget).

- **Publicly accessible integrated data and analytical space for data and interoperability** of intelligent transport systems across all transport modes.

- **Financing and participation of Slovak entities in co-financed international projects and European partnerships** such as Europe's Rail Joint Undertaking, CHIPS Joint Undertaking, Smart Networks and Services Joint Undertaking, Connected, Cooperative and Automated Driving Partnership, NATO DIANA, European Digital Infrastructure Consortia in mobility and logistics, etc.

2.2 Priority Area 2-2: Sustainable Mobility

Transformational goal of the priority area 2-2

Support research, development, and innovation for the widespread adoption and use of vehicles powered by alternative fuels and to ensure the availability of sustainable transport modes within a multimodal and integrated transport system.

Current state of the of priority area 2-2

- **There is a lack of sufficient physical and information** infrastructure for vehicles powered by alternative fuels, relative to development trends in the EU.

- According to statistics from SEVA (Slovak Electric Vehicle Association), the **public charging infrastructure in Slovakia reached 1,808 public charging points in 2023**, with a year-on-year increase of 22% compared to 2022, spread across 740 locations. Regionally, the **network covers all self-governing regions of Slovakia with the following share of stations**: 22% Bratislava Region; 14% Prešov Region; 12% Košice Region; 11% Nitra Region; 11% Trenčín Region; 10% Žilina Region; 10% Banská Bystrica Region; 10% Trnava Region. Within the EU27 plus the UK, **Slovakia ranks 1st in the ratio of public charging stations to electric vehicles**.[54] However, this is based on **the low share of electric vehicles in the Slovak vehicle fleet, which ranks 23rd in the EU in terms of EV percentage of total vehicles.**

- **Based on data on the share of battery electric vehicle registrations** in Europe in 2023, **Slovakia ranks last (27th) among EU countries** with 2.7% share (EU average 14.6%).[55] In Slovakia, registrations of new commercial vehicles increased by 18.6% in 2023 compared to 2022, of which only 2.8% were EVs (EU

[54] European Union: Competition analysis of the electric vehicle recharging market across the EU27 + the UK. Available at: https://op.europa.eu/en/publication-detail/-/publication/c9f5b4eb-72ee-11ee-9220-01aa75ed71a1
[55] SEVA – Number of battery electric passenger cars (M1) in Europe in 2023. Available at: https://seva.sk/efleetday24/

average 7.38%). Registrations of medium and heavy commercial vehicles (>3.5 tons) increased by 24.7%, but EVs accounted for only 0.3% (EU average 1.5%). Registrations for new buses increased by 101.3%, with only 0.1% being EVs (EU average 15.8%).[56]

- **R&D organizations do not achieve sufficient performance in expanding the usability and feasibility of technologies needed for decarbonizing transport** that industry can absorb.

- **Transport is a significant contributor to greenhouse gas and pollutant emissions** in Slovakia, accounting for up to 18% of total emissions, i.e., 7,523 Gg CO2 equivalent (2021). These emissions have increased by more than 10% since the base year 1990 and by 7% year-on-year compared to the COVID-19 year 2020. Road transport accounts for over 97% of these emissions.[57]

- Slovakia **lacks its own R&D centers in the automotive industry**, and only a limited portion of R&D is transferred from multinational companies to Slovak enterprises. This trend is currently limited by the **shortage of human resources and research capacities** at universities and research institutes in the required fields. This problem is linked to **insufficient motivation in Slovak science to focus on research areas critical for increasing Slovakia's competitiveness** in zero-emission vehicle production[58] (such as batteries, electric motors, etc.).

- **The Slovak industry** is strongly tied to the automotive sector and **needs to concentrate R&D efforts of technical universities and research centers** on areas that will help maintain the competitiveness of the European automotive industry. The transformation of the automotive industry to zero-emission vehicles[17] is a key challenge for the Slovak automotive industry to maintain its market share.[59, 60]

- **Export restrictions in international trade of critical raw materials are an increasing problem for the transformation of the Slovak automotive industry**. Export restrictions (quotas, taxes, minimum export prices, licenses)[61] have increased fivefold in the last 10 years. Slovakia ranks among the top 3 countries worldwide importing critical raw materials necessary for mobility decarbonization.[62]

- **Limited availability and integration of digital services** (e.g., issuing multimodal tickets and reservations in public transport, booking train paths for national and international passenger and freight transport, etc.) **and real-time information availability** are insufficient for flexible, data-driven decision-making in transport mode choice (e.g., environmental impact and other externalities of mode selection).

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[56] ACEA-New commercial vehicle registrations, European Union, Available at: https://www.acea.auto/files/Press_release_commercial_vehicle_registrations_2023.pdf
[57] SHMÚ – Air Quality Section: Total greenhouse gas and pollutant emissions in Slovakia. Available at: https://oeab.shmu.sk/emisie/celkove/trendy.html
[58] Alternative fuels defined in the European Parliament and Council Regulation (EU) 2023/1804 on the deployment of infrastructure for alternative fuels, according to Article 2 point 4a) zero-emission alternative fuels: electricity, hydrogen, ammonia, and 4b) renewable fuels: biomass fuels including biogas and biofuels as per Article 2 points 27, 28, and 33 of Directive (EU) 2018/2001, synthetic and paraffinic fuels including ammonia produced from renewable energy sources.
[59] Key timelines for large-scale electric vehicle production in Slovakia according to ZAP SR: Kia in 2025 and 2026, Volkswagen in 2026, Stellantis already manufactures electric vehicles in Trnava, Jaguar Land Rover from 2025 to 2030. Volvo will start (only) electric vehicle production in 2027, announced battery production for electric Porsche in Horná Streda is planned for 2026, and investment by Chinese Gotion and the Inobat consortium in a battery plant in Šurany is expected by 2027.
[60] Adapt Institute and CIPE European Office: Transformation of the Slovak automotive industry in the new geo-economic era. Available at: https://www.adaptinstitute.org/wp-content/uploads/2024/02/Transformacia-slovenskeho-automobiloveho-priemyslu-v-novej-geo-ekonomickej-ere.pdf
[61] IRENA – Geopolitics of the energy transition: Critical materials. Available at: https://www.irena.org/Publications/2023/Jul/Geopolitics-of-the-Energy-Transition-Critical-Materials
[62] Kowalski, P. and C. Legendre (2023), "Raw materials critical for the green transition: Production, international trade and export restrictions", OECD Trade Policy Papers, No. 269, OECD Publishing, Paris. Available at: https://doi.org/10.1787/c6bb598b-en.

Thematic Support Area in the Priority Area 2-2

Mobility for the 21st Century	
Priority Area 2-2: Sustainable Mobility	2.1.1. Innovative solutions supporting an increased share of passengers and freight transported by rail
	2.1.2. Research, development, and implementation of materials, systems, and technologies applied in zero-emission vehicles
	2.1.3. Research, development, and implementation of innovations focused on drives using alternative fuels with zero emissions and alternative fuels from renewable sources, including research and development of these fuels
	2.1.4. Development and implementation of services and solutions reducing negative impacts on the environment, number of deaths and serious injuries, or time spent in transport
	2.1.5. Data-driven solutions for energy efficiency and decarbonization of transport and logistics

Target state of the Priority Area 2-2

- **Availability and feasibility (removal of barriers) for the operation of infrastructure** (charging and refueling stations) for alternative fuels.
- **Higher share of vehicles using alternative fuels** in individual and public transport as well as in logistics and freight transport.
- **Increased cooperation on joint projects** in mobility decarbonization between **academic institutions and industry** (both domestically and internationally).
- **Reduced share of emissions from transport** in total emissions through the application of innovative solutions introducing zero-emission and low-emission transport systems and technologies.
- **Increased number of processes, products, or technological innovations** in companies contributing to mobility decarbonization.
- **Increased share of passengers and freight transported by rail**[63] due to innovative solutions and approaches for introducing multimodality, such as more efficient multimodal hubs and the implementation of modular (multi-purpose) transport systems and vehicles that increase flexibility in transport.

[63] European Commission: Sustainable and Smart Mobility Strategy. Available at: https://transport.ec.europa.eu/transport-themes/mobility-strategy_en

- **Higher added value and cost-effectiveness**[64] in the economy **through shifting a certain share of road passenger and freight transport to rail transport.**[65, 66]

- **Introduction of new services** aimed **at reducing the negative impacts of transport on the environment, reducing deaths and serious injuries** caused by transport, reducing time spent on passenger and freight transport, and **increasing energy efficiency** in transport.

- **Financing and participation of Slovak entities in co-financed international projects and European partnerships** such as Clean Hydrogen Partnership, BATT4EU Partnership, 2ZERO Partnership, DUT Partnership, EIT Urban Mobility, etc.

Table 1: Essential Prerequisites for the Implementation of Domain Mobility for the 21st Century

Name of Prerequisite	Description of Prerequisite
Development and application of innovative business models in mobility	Support for implementing tools and innovative solutions to improve efficiency in transport and logistics, which are not only cost-effective but also environmentally friendly. Such tools/solutions include innovative business models like on-demand mobility/logistics, Mobility as a Service (MaaS), shared mobility, vehicle subscription, etc.
Open access to data from projects funded by European sources	Ensuring access to scientific information, such as peer-reviewed publications, research data, etc., obtained or created from projects funded by European sources within the domain Mobility for the 21st Century, in line with open access practices, which are not protected by intellectual property rights and whose publication does not conflict with the EU General Data Protection Regulation (GDPR) or classified information protection.
Legislative adjustment reflecting project implementation	Changes in legislation and further legal regulations necessary for enabling the implementation of projects funded by European sources within the domain Mobility for the 21st Century and ensuring their sustainability.
Development of multimodal and integrated transport and transport optimization	Support for the introduction of tools and solutions for integrated and multimodal transport, connecting various transport modes and contributing to improved transport conditions (reducing time spent in traffic jams, increasing safety, lowering infrastructure maintenance costs).

[64] Based on a Deloitte study conducted for Belgium, it is demonstrated that every euro invested in railways generates approximately 3 euros for the economy. Nota aan de Federale Regering België, November 2020: Analyse van de economische en duurzame impact van Infrabel ©2020 Deloitte Belgium. At the same time, compared to road transport, rail transport is 7 times more energy efficient and produces 9 times less CO2 emissions. Available at https://www.cer.be/images/publications/reports/CER_-_ON_TRACK_FOR_EUROPE_MANIFESTO.pdf and https://www.railfreightforward.eu/sites/default/files/downloadcenter/whitepaperldupdated.pdf

[65] According to data from the European Rail Supply Industry Association (UNIFE) for 2019, the railway supply industry in Europe generated a turnover of approximately 77 billion euros and employed about 400,000 people.

[66] Based on the goals defined in the WHITE PAPER Roadmap to a Single European Transport Area, the EU targets for freight transport over 300 km are: Shift 30% of road freight transport over 300 km to other modes of transport by 2030 and Shift 50% of road freight transport over 300 km to other modes of transport by 2050. Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0144:FIN:en:PDF

Digital transformation of Slovakia

3 Digital Transformation of Slovakia

The goal of the Digital Transformation of Slovakia domain is:

- Develop entrepreneurial activities in sectors of the digital economy where there is potential to become a leader in the European market and a sufficient base of companies cooperating with research teams.
- Increase the competitiveness of businesses, increase added value, and improve cooperation between the public and private sectors.
- Network research teams in priority areas with the commercial sector to achieve effective transfer of research, development, and innovations into practice and the application of the latest knowledge throughout society.
- Develop and expand the base of top experts in Slovakia focusing on applied research, development, and digital innovations.
- Support the implementation of digital technologies and solutions in society to increase the security and added value of data generated by digital technologies, and the applied use of technologies such as artificial intelligence, supercomputers, and virtual and augmented reality.
- Increase emphasis on integrating digital technologies across all sectors of the economy, as opposed to developing digital technologies as a standalone industry, and integrate digital technologies throughout all parts of society.
- Support research, development, and implementation of technologies defined in STEP (Strategic Technologies for Europe Platform) in line with the goals of this domain.
- Finance and ensure the participation of Slovak entities in co-financed international projects and European partnerships such as EuroHPC, EuroQCI, etc.

3.1 Priority Area 3-1: Intelligent and Connected Systems and Internet of Things Devices

Transformational goal of the 3-1

Increase society's ability to make data-driven decisions from the level of individual decisions, through automated workplaces in enterprises, up to the level of critical state infrastructure, environmental management, and urban infrastructure, using various methods including machine learning and artificial intelligence.

Current state of the priority area 3-1

- Insufficient utilization of sensor data collection systems, resulting in lower resource efficiency across all economic sectors.

- Up to 80% of data processing and analysis takes place in data centers and centralized computing facilities, with only 20% happening in intelligent connected objects such as automobiles, household appliances, manufacturing robots, and in computing devices close to the users (edge computing).[67]

- Inadequate public administration information systems for data processing and analysis in the areas of environment, technical infrastructure, industry, and healthcare, coupled with a low level of data sharing between organizations.

[67] European Commission: White Paper on Artificial Intelligence – A European approach to excellence and trust. Available at: https://eur-lex.europa.eu/legal-content/SK/TXT/PDF/?uri=CELEX:52020DC0065

- Unavailable non-personal databases for artificial intelligence training needs in fields like transport, healthcare, and environment, which would be compatible with data sources in other EU countries (digital twins of physical systems).

- Slovakia is approaching the EU average in terms of digitally offered public services, which according to EC statistics is on the rise.[68] However, low level of personalized products and services remains a problem.

- Slovakia has an above-average level of e-government users compared to the EU, at 81%. Nearly 4 million people (or about 72% of citizens) have access to the electronic identification system (eID), which was notified by the European Commission under the eIDAS regulation.

Thematic Support Area in the Priority Area 3-1

Digital Transformation of Slovakia	
Priority Area 3-1: Intelligent and Connected Systems and Internet of Things Devices	3.1.1. Embedded systems and Internet of Things (IoT)[69]
	3.1.2. Development and integration of systems for data collection, processing, and distribution
	3.1.3. Research, development, innovation, and implementation of intelligent products and services

Target state of the Priority Area 3-1

- Mass deployment of sensors for sensing environmental properties and their use in systems. This includes, for example, integration with the development of robots and industrial monitoring devices.

- Increased data collection and analysis in intelligent connected objects such as automobiles, household appliances, manufacturing robots, and edge computing devices near users.

- Development and deployment of intelligent systems embedded directly into devices and end products, which through the Internet of Things provide high added value.

- Implementation of intelligent and innovative solutions in local governments that improve citizens' quality of life and increase the quality and efficiency of public services provided by public administration through technology.

- Deployment of intelligent systems in educational and healthcare facilities to help streamline operations and provide advanced operational services.

- Emergence of new innovative solutions and new companies in the development of IoT devices and their components as well as data products and services.

- Strengthened capability to make data-driven decisions, through automated workplaces in enterprises, up to the level of critical state infrastructure, including environmental and urban infrastructure using statistical methods and machine learning.

[68] Commission: Country Report 2023 – Slovakia. Available at: https://op.europa.eu/sk/publication-detail/-/publication/2e83a698-fa2f-11ed-a05c-01aa75ed71a1/language-sk

[69] A designation for devices equipped with sensors connected to a network (often wireless) that are capable of monitoring environmental properties and performing automated tasks. In practice, this category also includes consumer devices for smart homes, industrial and healthcare technologies, and others.

- Public administration collects and evaluates information on the state of environmental components and technical and network infrastructure in the state based on continuously collected data in modern information systems, enabling optimal maintenance and renewal planning.

- Benefits resulting from better data utilization, including increased productivity and resource efficiency, as well as improvements in health and well-being, environment, transparent governance, and efficiently provided public services.

- When implementing investments within Priority Area 3-1, which have identified thematic horizontal links with the domains Innovative Industry for the 21st Century, Mobility for the 21st Century, Healthy Society, and Food Competitiveness and Climate Resilience, the target state is to support such RDI projects that provide solutions simultaneously reflecting multiple thematic support areas with mutual linkages.

3.2 Priority Area 3-2: Increasing the Utility Value of All Types of Data and Databases

Transformational goal of the Priority Area 3-2

Using advanced information tools to increase the utilization of existing data sources for processing data from existing structured and unstructured sources as well as newly emerging large databases, which will form the basis for high added-value solutions.

Current state of the Priority Area 3-2

- In sectors such as industry, commerce, healthcare, or the public sector, there is a large amount of high-quality non-personal data the potential of which is underutilized, with the volume expected to further increase in the coming years.[70]

- Low usage of advanced information tools for processing large databases in SMEs and the public sector.

- Low usage of real-time information processed through predictive machine learning, for example, in manufacturing or healthcare sector.

- Low rates of reuse and provision of data in existing databases—there are many high-quality non-personal data with potential that remains unfulfilled, such as data from industry, commerce, or the public sector.

- Two-thirds of monitored public administration entities publish the minimum set of open data on data.slovensko.sk. Only 23% of monitored services reconcile incoming data with reference data. There is a low level of data quality in registries providing reference data (rated 2 out of 4). [71]

- Low automation levels for processing textual and speech data in the Slovak language; natural language processing is limited due to the restricted scope of language models for Slovak and insufficient attention from global providers to smaller languages. There is inadequate focus on document processing in Slovak and on integrating publicly available large language models to create unique applications based on domain-specific Slovak language.

[70] NKIVS – National Concept of Public Administration Informatization of the Slovak Republic 2021. Available at: https://mirri.gov.sk/wp-content/uploads/2021/12/Narodna-koncepcia-informatizacie-verejnej-spravy-2021.pdf

[71] Ministry of Investments, Regional Development and Informatization of the Slovak Republic: National Concept of Public Administration Informatization of the Slovak Republic. Available at: https://mirri.gov.sk/wp-content/uploads/2021/12/Narodna-koncepcia-informatizacie-verejnej-spravy-2021.pdf

Thematic Support Area in the Priority Area 3-2

Digital Transformation of Slovakia	
3-2: Increasing the Utility Value of All Types of Data and Databases	3.2.1. Natural language processing in Slovak and interpretation of informational content
	3.2.2. Processing and visualization of data obtained from industrial or commercial processes
	3.2.3. Innovative forms of presentation using virtual and augmented reality

Target state of the Priority Area 3-2

- The public sector in Slovakia is fully digitalized, enabling citizens and businesses to utilize efficient and modern digital services. Data from public institutions is processed and shared through integrated digital platforms, increasing transparency, efficiency, and accessibility of services for all residents. Digital and data technologies are fully integrated into all areas of society and the economy, leading to increased productivity, innovation, and quality of life. Slovakia fully exploits the potential of data within digital transformation and is becoming a leader in data-driven innovation in the region. National data centers are modern, highly available, and scalable facilities that provide secure and efficient data storage and processing for public institutions, businesses, and citizens. These centers are equipped with the latest technologies to optimize performance and energy efficiency, considering ecological aspects and sustainability. National data centers act as catalysts for innovation and research, providing access to analytical tools and technologies that enable processing of large data volumes and support collaboration among businesses, research organizations, and public institutions, thereby increasing competitiveness and innovation in the country. They enable Slovakia to effectively manage its data, support innovation, and ensure protection of sensitive information in the digital age.[72]
- Academic institutions and industrial enterprises in Slovakia closely cooperate on research and development projects focused on the use of data technologies. This cooperation leads to effective transfer of innovations and technologies into practice, significantly increasing the competitiveness of Slovak enterprises and supporting sustainable growth of a data-driven economy.
- Small and medium-sized enterprises (SMEs) in Slovakia utilize data technologies such as big data analytics, artificial intelligence, and the Internet of Things (IoT) to streamline their manufacturing and business processes. SMEs have access to digital tools and consulting services that enable them to make better decisions, increase productivity, and improve competitiveness in international markets. National data centers are modern, highly available, and scalable facilities that provide secure and efficient data storage and processing for public institutions, businesses, and citizens. These centers are equipped with the latest technologies to optimize performance and energy efficiency, while considering ecological aspects and sustainability. National data centers serve as catalysts for innovation and research, providing access to analytical tools and technologies that enable the processing of large data volumes and support collaboration between companies, research organizations, and public institutions, thereby increasing the country's competitiveness and innovation. They enable Slovakia to effectively manage its data, support innovation, and ensure the protection of sensitive information in the digital age.

[72] Reference strategic documents Digital Agenda for Europe https://www.europarl.europa.eu/factsheets/sk/sheet/64/digitalna-agenda-pre-europu and The European Data Strategy https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-data-strategy_en and Digital Transformation Strategy of the Slovak Republic 2030 https://mirri.gov.sk/wp-content/uploads/2019/10/SDT-English-Version-FINAL.pdf

- Information tools are used for processing, presenting, and sharing large volumes of data for the benefit of businesses, the public sector, and research.
- Manufacturing processes utilize digital twins — digital replicas of the real world — which provide workers with real-time information to identify potential risks or failures, for example through virtual and augmented reality tools.
- Users leverage data analysis to predict potential risks or failures of components in production, which increases their productivity through predictive maintenance.
- Enterprises and other entities obtain the basis for operational and strategic decisions based on well-processed and clearly presented data analyses and predictions.
- The use of digital archives (e.g., in healthcare, cultural heritage, meteorology, etc.) as well as other digitized data provides opportunities for the development of service industries with international significance. It offers effective tools for recording, cataloging, and utilizing large volumes of data about real-world objects, which are used in global markets (for example, in the gaming and film industry, healthcare, and energy sectors).
- Utilization of language technologies for interaction and document processing in Slovak applications, including the use of semantic search in multilingual and multimodal environments.
- Companies and researchers are among the leaders in utilizing sophisticated machine learning methods for situations where it is necessary to work with limited or incomplete data.
- The use of sound and image recognition algorithms helps people with sensory disabilities in everyday life through integration into the existing ecosystem of wearable electronics.
- Combinations of structured/unstructured, historical/online, proprietary/commercially available data from various sources are used, including open databases and open science.
- The development of sophisticated machine learning methods for situations requiring work with limited or incomplete data. The application of these methods will increase the utility value of collected but so far unused smaller datasets and datasets gathered by smaller economic entities or institutions.
- Intersection with the domain Healthy Society: Healthcare professionals use digitized real-time data, including natural language processing in healthcare. Digital data will be usable for subsequent analysis and the creation of variant models aimed at improving the quality and efficiency of healthcare in prevention, diagnostics, treatment, and follow-up care.
- In implementing investments under priority area 3-2, where thematic horizontal links have been identified with the domains Innovative Industry for the 21st Century, Mobility for the 21st Century, Healthy Society, and Food Competitiveness and Climate Resilience, the target state is to support R&D projects that provide solutions reflecting multiple thematic support areas with mutual interconnections.

3.3 Priority Area 3-3: Intelligent Energy Systems

Transformational goal of the Priority Area 3-3

Accelerate the transition to a more efficient and environmentally friendly energy mix by creating tools for the operation of distribution systems and networks, including local energy communities and independent entities, which will serve producers and consumers by maximizing reliability, cost-effectiveness of operation, and market efficiency not only in electricity but also in gas, heating, water supply, and manufacturing sectors.

Current state of the Priority Area 3-3

- Insufficient collection, analysis, and utilization of data to achieve energy savings represents a challenge for Slovakia in fulfilling European commitments stemming from its membership in the European Union. The need to leverage cost-effective energy-saving opportunities is part of the Clean Energy for All Europeans package, which introduced a new primary EU energy efficiency target of at least 32.5% by 2030 compared to projected energy consumption in 2030.[73]
- Slovakia set a target in its Integrated National Energy and Climate Plan 2021-2030 to achieve a 19.2% share of energy from renewable sources by 2030.[74] Based on the climate plan revision and European directives, this ambition was increased to 23% in 2023.[75] The European Commission considers even this target insufficiently ambitious and demands an increase to 35%. Achieving and managing the expected increase in the share of renewable energy sources will require new and innovative ways to manage distribution systems.
- Slovakia is lagging in innovation activities in the field of intelligent energy systems. Progress in the installation of smart meters is comprehensively reported by the Regulatory Office for Network Industries (ÚRSO) in its annual reports.
- The thermal energy sector is moving towards decarbonization and decentralization by utilizing waste heat from industrial production and increasing the integration of renewable energy sources.
- Distribution networks need to be modernized. This will enable the use of new products (such as sharing and aggregation of flexibility) among market participants (active consumers).
- The risk of energy poverty threatens low-income households. In Slovakia, one in four households below the poverty line cannot maintain adequate heating in their homes. In neighboring countries, this proportion is significantly lower – 10% of households in Poland and Hungary, 7% in the Czech Republic, and 5% in Austria among those below the poverty line have problems maintaining appropriate temperatures in their homes.[76]
- The energy sector is undergoing a transformation towards digitization and decentralization, requiring modernized tools for managing energy systems as well as systems for billing and settlement based on standardized, interoperable, flexible, and non-duplicative data exchange/sharing between energy market participants.
- Slovakia is well connected with its neighbors regarding electricity. Investments are focused on smart grids and modernization of distribution networks to better integrate renewable energy sources.[77]
- The increasing number of integrated decentralized energy sources and storage systems requires more complex control systems and systems to support the operation and maintenance of these networks. For example, in 2024 Slovakia launched the largest battery storage facility with a capacity of 2.7 MW in Banská Bystrica, which can replace fossil sources and provide support services for grid stability. This storage

[73] European Parliament: Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955. Available at: https://eur-lex.europa.eu/legal-content/SK/TXT/?uri=OJ%3AJOL_2023_231_R_0001

[74] Ministry of Economy of the Slovak Republic: Integrated National Energy and Climate Plan for 2021-2030. Available at: https://www.mhsr.sk/energetika/integrovany-narodny-energeticky-a-klimaticky-plan-na-roky-2021-2030

[75] European Commission: Slovakia - Draft Updated NECP 2021-2030. Available at: https://commission.europa.eu/publications/slovakia-draft-updated-necp-2021-2030_en?prefLang=sk

[76] Slovak Academy of Sciences: Energy poverty is a problem that requires urgent solutions. Available at: https://www.sav.sk/?lang=sk&doc=services-news&source_no=20&news_no=12066

[77] European Commission: Country Report 2023 – Slovakia. Available at: https://op.europa.eu/sk/publication-detail/-/publication/2e83a698-fa2f-11ed-a05c-01aa75ed71a1/language-sk

facility can annually prevent the production of approximately 361 tons of CO2. Technological advances in battery systems and their declining costs make these solutions an alternative for decentralized energy sources.[78]

- Slovak legislation (transposing European energy directives) supports new market participants (active consumers, energy communities, aggregators), for whom new products for buying and selling energy using AI and data exchange through the Energy Data Center (EDC) can be created.

- The broader use of so-called "energy sector coupling" is beginning — the integration of different energy sectors (e.g., electricity, gas, heat, cooling, mobility, industrial energy surpluses), facilitating the integration of a higher share of renewable energy sources into the energy mix through increased system flexibility.

- Slovakia, as a country with a high share of energy consumption in industry and energy-intensive operations, serves as a natural laboratory for innovative solutions in smart management of primary energies, reuse of energy potential of various media, and algorithmic distribution of energy in various forms supported by innovative methods. According to the Institute of Economic Analyses of the Ministry of Economy of the Slovak Republic, Slovakia has one of the most dynamic declines in industrial energy intensity among EU countries since 1995.[79] The largest shares of final energy consumption in industry in 2021 were electricity (29.5%) and natural gas (24.6%). Consumption of industrial gases represented 11.8%, renewable energy sources and biofuels 9.8%, oil and oil products 9.3%, solid fuels 8%, non-renewable waste 5.1%, and heat 2%.[80]

Thematic Support Area in the Priority Area 3-3

Digital Transformation of Slovakia	
3-3: Intelligent Energy Systems	3.3.1. Systems supporting the integration of renewable energy sources, various types of energy storage, and charging stations for electric vehicles into energy systems (from planning to operation, management, and maintenance)
	3.3.2. Intelligent management of production, accumulation, and consumption in multi-energy systems with the support of active consumers and energy communities
	3.3.3. Prediction of energy production and consumption, including anomaly detection using artificial intelligence (AI)
	3.3.4. New and innovative energy products in the transformed energy market and innovative solutions for energy storage management

Target state of the Priority Area 3-3

- Legislation supports the conditions for the operation of decentralized energy systems.

- The importance of technologies such as AI and intelligent metering systems in the energy sector is increasing demand for them.

[78] The largest battery storage facility that can replace fossil fuel sources has been launched in Slovakia.
[79] SITA-Industry. Slovakia is succeeding in reducing the energy intensity of industry, one of the most dynamic declines among EU countries since 1995. Available at: https://sita.sk/vpriemysle/slovensku-sa-dari-v-znizovani-energetickej-narocnosti-priemyslu-ide-o-jeden-z-najdynamickejsich-poklesov-z-krajin-unie-od-roku-1995/
[80] Enviroportal – Final energy consumption in industry. Available at: enviroportal.sk/indicator/detail?id=1021&print=yes

- Companies can increase the energy efficiency of their operations through modern digital tools and participate in the energy market, for example by utilizing aggregator services.

- Accelerated transition to a more efficient and environmentally friendly energy mix and charging infrastructure for electromobility.

- The tools for the operation of distribution systems and networks serve large numbers of producers and consumers with high reliability and cost-effectiveness of operation and efficiency of the energy market and have applications in the gas, heating and water industries.

- Slovak research capacities in intelligent energy systems are applied in innovative practical applications, with the resulting innovative products and services representing significant export opportunities for system developers.

- Research, development, and implementation of innovative solutions in energy support the development of low-emission and local energy systems.

- In the implementation of investments within priority area 3-3, where thematic horizontal links with domains Innovative Industry for the 21st Century, Mobility for the 21st Century, Healthy Society, and Food Competitiveness and Climate Resilience have been identified (as described in Chapter 6: Synergies and Complementarities of SK RIS3 2021+ domains), the target state is to support such RDI projects that provide solutions simultaneously reflecting multiple thematic support areas with mutual links.

3.4 Priority Area 3-4: Cybersecurity and Cryptography

Transformational goal of the Priority Area 3-4

Build a secure information society that utilizes modern technologies and can defend itself against cyberattacks while promoting cyber hygiene. Businesses and other entities should have access to digital solutions in which security is an integral part, so they do not have to address data and network protection, production continuity, and defense against cyberattacks through additional follow-up projects.

Current state of the Priority Area 3-4

- Slovakia lags in the implementation of cybersecurity systems and crisis management. As a result, Slovakia ranks low in the National Cybersecurity Index (NCSI). In 2024, Slovakia ranked 13th with an index score of 80.83.[81]

- With digitalization and the introduction of new innovative technologies such as AI, IoT, HPC, and 5G, the vulnerability of companies, citizens, and public authorities increases. In 2023, 974 incidents were reported, almost 60% related to information theft. Although there was an almost 4% year-on-year decrease in reported incidents, more severe attacks such as denial-of-service or botnets are on the rise.

- There are gaps in the development of advanced equipment, tools, and data infrastructures in cybersecurity. Outdated ICT equipment is one of the problems in securing systems in government institutions. The Slovak National Cybersecurity Center recorded 131 cybersecurity incidents in healthcare in 2021.[82]

[81] NCSI-National Cyber Security Index-Slovakia. Available at: https://ncsi.ega.ee/country/sk/

[82] Central European Digital Observatory. Available at: https://cedmohub.eu/sk/tri-stvrtiny-sloveniek-a-slovakov-vnimaju-sirenie-dezinformacii-ako-hrozbu-pre-bezpecnost-slovenska/

- There is potential for the development of cybersecurity technologies such as cryptography, quantum security, blockchain, and natural language processing.
- Disinformation spreads in the information space. Up to 39% of the population feels exposed to disinformation, and as many as 76% perceive disinformation as a threat to Slovakia's security.[83]

- Insufficient resilience against cyberattacks, low awareness of risks, and limited dissemination of cybersecurity knowledge. In 2022, 64 incidents were reported in industry and industrial processes, including 22 cyberattacks with actual physical consequences, representing a 144% year-on-year increase.

- Cybersecurity assurance for the reliable operation of critical state entities is not systematically guaranteed for all actors according to international standards.

- Implementing robust security measures and procedures helps minimize the likelihood of outages and financial losses. Nearly one-third (31.3%) of SMEs manage their cybersecurity themselves, even though legislation does not require it. Up to 78% of companies operating operational technologies (OT) have experienced at least three attacks in the last 12 months.[84]

Thematic Support Area in the Priority Area 3-4

Digital Transformation of Slovakia	
3-4: Cybersecurity and Cryptography	3.4.1. Quantum key distribution and implementation of new encryption algorithms
	3.4.2. Distributed ledger technologies
	3.4.3. Prevention of disinformation and cyber hygiene in the information space
	3.4.4. AI Cybersecurity systems in enterprises utilizing AI elements

Target state of the Priority Area 3-4

- Increased awareness among vulnerable population groups regarding the use of technologies, products, and services for protecting personal data, preventing online fraud, and responding to cyber threats.

- High resilience of enterprises, citizens, and public authorities against cyberattacks.
- Use of advanced tools and data infrastructures in the field of cybersecurity.

- AI and IoT systems will be trusted by citizens and businesses, supporting the use of online services, applications, and products based on innovative technologies.

- A thriving open data economy with extensive reuse of data thanks to high cybersecurity standards.

- Cyber hygiene ensures adherence to measures preventing the spread of disinformation, including combating cyberbullying in schools. Societal resilience against disinformation spread through natural language processing tools is vitally important to maintain essential state and societal services.

[83] Central European Digital Observatory. Available at: https://cedmohub.eu/sk/tri-stvrtiny-sloveniek-a-slovakov-vnimaju-sirenie-dezinformacii-ako-hrozbu-pre-bezpecnost-slovenska/
[84] International Trade Administration-Slovakia information technology cybersecurity opportunities. Available at: https://www.trade.gov/market-intelligence/slovakia-information-technology-cybersecurity-opportunities

- Deployment of innovative cybersecurity solutions: quantum key transmission, post-quantum encryption, and blockchain.

- General use of natural language processing and interpretation of informational content.

- Enterprises and other entities have access to digital solutions where security is an integral part, so they do not have to address data and network protection, production continuity, and cyberattack defense through additional projects.

- Slovakia hosts firmware developers and solution providers for regular updates of embedded systems, especially those with wireless communication layers that utilize post-quantum cryptography and are built on open-source code.

- When implementing investments in Priority Area 3-4, which have identified thematic horizontal links with the domains Innovative Industry for the 21st Century, Mobility for the 21st Century, Healthy Society, and Food Competitiveness and Climate Resilience, the target state is to support such RDI projects that provide solutions simultaneously reflecting multiple thematic support areas with mutual connections.

Healthy Society

4. Healthy Society

The goal of the Healthy Society domain is:

- Improve the quality and efficiency of healthcare by linking healthcare with research, development, and innovation (RDI) areas.
- Include biomedicine and digital healthcare solutions in emerging economic sectors with the potential to become significant pillars of future economic growth.
- Create a sustainable financing model for RDI in healthcare that will support excellent interdisciplinary teams and activities on a long-term and continuous basis, with multi-source financing — state budget, EU funds, Recovery Plan, other grant financing, and private sector investments.
- Develop and implement an innovative reimbursement mechanism model aimed at accelerating the integration of innovations into the reimbursement system of health insurance companies.
- Establish an interactive and regularly updated map of biomedical and clinical research and digital medicine that provides a comprehensive overview of the steps necessary for their successful introduction into (clinical) practice.
- Complete infrastructures at the international level focused on research and the provision of innovation-based healthcare.
- Support the establishment, operation, and development of a national network of clinical research and biobanking units, which are fundamental pillars of RDI in health.
- Create strong/extensive data models and increase data availability to support cutting-edge RDI solutions in health.
- Complete the infrastructure for genomic and other OMICs methods and their application in diagnosis and treatment within the scope of a single disease.
- Create a better working environment for scientific and research staff in healthcare, including biomedicine, improve their motivation, and expand opportunities for their career advancement.
- Create and develop an inspiring, motivating, attractive, and sustainable environment to retain and bring back Slovak researchers and experts in healthcare, including biomedicine.
- Strengthen continuous and sustainable cooperation between academic researchers, healthcare providers, and the private sector.
- Improve inter-ministerial cooperation, functional management, reduce/eliminate bureaucracy, and simplify the implementation of RDI projects and their results into healthcare practice.
- Enhance the effectiveness of the legislative, organizational, and procedural environment to significantly increase spending on RDI in healthcare to at least the average level of the other three V4 countries.
- Improve support for SMEs, startups, and spin-offs focused on healthcare (e.g., through access to existing research infrastructure, financial support for company creation and development, expert support, fostering collaboration, etc.).
- Support RDI and the implementation of digital solutions into clinical practice, which is key for modernizing and streamlining healthcare. Digital solutions can improve diagnosis, treatment, patient monitoring, and communication among healthcare professionals.
- Enhance support for biomedical and biotechnology centers/clusters that play a decisive role in the growth and development of industry and the knowledge economy in Slovakia by creating synergies and platforms for collaboration among the academic community, healthcare providers, industry, private sector, policymakers, and investors.
- Strengthen and develop international cooperation and the internationalization of Slovak RDI (Research, Development, and Innovation) in the health sector, including Slovakia's participation **in European partnerships, membership** in relevant ESFRI research infrastructures, and continuous support for project activities of their national nodes (including the already established SLOVACRIN).
- Ensure priority support for projects approved as 'Important Projects of Common European Interest (IPCEI)' in the fields of biotechnology, health innovations, and advanced therapeutics manufacturing.
- Support research, development, and implementation of technologies defined in the STEP (Strategic Technologies for Europe Platform) and aligned with the goals of this domain.

- Implement priority project activities with the potential for direct clinical practice application based on clearly structured criteria.
- Provide systemic support for financing the RDI ecosystem across all regions of Slovakia, including the Bratislava region.
- Ensure the revision of legal norms reflecting the strategy for systemic support to improve RDI quality, development of biomedical translational, preclinical, and clinical research, and biobanking, funded from European and national sources, whose outputs have the potential to significantly improve the quality and efficiency of healthcare provision in Slovakia as well as globally, including:
  - amendment of Act No. 576/2004 Coll. supporting biobanking and biomedical research,
  - amendment of Act No. 525/2010 Coll. on the provision of subsidies within the competence of the Ministry of Health of the Slovak Republic,
  - amendment of Act No. 135/2013 Coll. on the National Health Information System and on the amendment and supplementation of certain laws,
  - adjustment of legislation to improve cooperation between the public and private sectors in healthcare.

4.1 Priority Area 4-1: Personalized/Precision Medicine

Transformational goal of the Priority Area 4-1

Create an environment and support the development of sustainable biomedical infrastructure and biomedical capacities to support research, development, and innovation (RDI) in the prevention, diagnosis, treatment (including biobanking — the storage of samples in biobanks with associated data), and subsequent care of diseases through comprehensive and/or infrastructural projects focused thematically on socially significant diseases (oncology, neurology, cardiovascular system, as well as rare, metabolic, and infectious diseases), leading to improved public health and quality of life.

Current state of the Priority Area 4-1

- Slovakia does not update and fully implement a strategic support system for thematic prioritization of biomedical research according to disease development trends in the population.

- Slovakia carries out a very low number of Academic Clinical Studies (ACS), which allow access to innovative treatments (without burdening health insurance companies) and strengthen the quality/prestige of clinical research in Slovakia as well as within international cooperation. The reason is the absence of continuous support for the academic sector and the clinical sphere in hospitals, start-ups/spin-offs, and a lack of professional consultancy in these processes and procedures.

- Slovakia does not have an optimized system for management, support, and monitoring of biomedical and clinical research (clinical trials), including the implementation of long-term and systematic financing of these areas.

- Slovakia lacks an effective coordination mechanism for the clinical research network, without which it is not possible to comprehensively and systematically support RDI (research, development, and innovation) and applications into clinical practice.

- Slovakia does not provide sufficient and continuous support for clinical research of new medical technologies (medicines, medical devices including software, modern therapy preparations such as gene, cell therapies, tissue engineering, as well as combined technologies including new treatment methods).[85]

- Slovakia lacks qualified personnel and some technological capacities to collaborate in complex research projects with clinical facilities.[86] Hospitals, given the current unfavorable conditions, processes, and environment for RDI, cannot offer attractive working conditions and environments for qualified personnel. Slovakia experiences a migration of students, recent graduates, and experienced experts abroad for better conditions despite physicians' salaries measured as a share of average national wages being comparable to foreign countries.[87]

- The RDI area in healthcare in Slovakia suffers from an inadequate model for setting up research-innovation centers, partly due to underfunding and inefficient systemic linkage to healthcare providers.

- Overall, Slovakia significantly lags in the protection and enforcement of intellectual property rights (IPR) compared to EU countries, including in biomedical research. Among V4 countries, Slovakia ranks last and in the international WIPO ranking is 61st in patents and 46th in trademarks and designs.88 A competitive environment with quality IPR protection is an important factor for investment decisions of companies operating in healthcare and biomedical research.

Thematic Support Area in the Priority Area 4-1

Healthy Society	
Priority Area 4-1: Personalized/Precision Medicine	4.1.1. National biobank network for biomedical research
	4.1.2. Creation of genomic centers, national genomic database (including newborn genomics program)[89]
	4.1.3. Implementation of digital innovations in healthcare
	4.1.4. Implementation of comprehensive research projects focused on prevention, diagnosis, treatment, and follow-up care[90]
	4.1.5. Development of clinical research

Target state of the priority area 4-1

- Established functional system for management, implementation, legislative framework, and processes for providing personalized medicine and its integration into the healthcare delivery system in healthcare facilities (university/faculty hospitals, specialized hospitals, relevant research institutes).

- Developed, continuously expanding, and sustainably managed national biobank network (biobank at Jessenius Faculty of Medicine, Comenius University in Martin, and local biobanks) supported by a

[85] This refers to the support of clinical trials of these technologies (testing on patients and/or validation in practice), including the implementation of long-term and systematic financing and/or support for investors in these areas.
[86] OPVaI – Long-term strategic research program for a specific specialization area from the perspective of available scientific and research capacities RIS3 SK. Available at
: https://www.opvai.sk/media/57232/strategický-program-vav-pre-biomedicínu-a-biotechnológie.pdf
[87] OPVaI – Long-term strategic research program for a specific specialization area from the perspective of available scientific and research capacities RIS3 SK. Available at
: https://www.opvai.sk/media/57232/strategický-program-vav-pre-biomedicínu-a-biotechnológie.pdf
[88] WIPO-Intellectual Property Fact Sheet 2022. Available at: https://www.wipo.int/edocs/statistics-country-profile/en/_list/l1.pdf
[89] The thematic support area for projects also includes the establishment of a genomic center for at least one disease.
[90] Within this priority area, comprehensive and infrastructure RDI projects focused on prevention, diagnosis, treatment, and follow-up care will be supported, primarily in the areas of the Health Mission — oncology, neurology, and the cardiovascular system — but also rare, metabolic, and infectious diseases.

functional digital biobank, co-financed also from state sources, including national programs targeting diseases with the highest morbidity and mortality in Slovakia (e.g., NOP, etc.).

- Setting rules/standards and adoption of a valid legislative framework for biobanking.

- Creation of a competitive and innovative environment for translational medicine and effective linking of RDI through application of the latest basic research knowledge into clinical practice, also through the creation of innovation centers in hospitals that would support cooperation among experts from clinical practice, R&D, and business.

- Established sustainable and competitive biomedical infrastructure and capacities to support research, development, and innovation (RDI) in prevention (including public health research), diagnostics, therapy, and follow-up care or patient monitoring within socially significant diseases, leading to improved population health, increased health literacy, and quality of life in Slovakia.

- Implementation of biomedical/clinical research projects and the introduction of RDI outputs in personalized medicine into clinical practice, prioritizing socially significant diseases such as oncology, neurosciences, cardiovascular system, rare, metabolic, and infectious diseases, as well as primary and secondary prevention across therapeutic areas; with potential project complementarities involving digitalization and intelligent IT solutions (bioinformatics, artificial intelligence, etc.).

- Support for RDI and implementation of new medical technologies (drugs, medical devices, including software, in vitro medical devices, modern therapies such as gene and cell therapies, tissue engineering), combined products, methods, and technologies using telemedicine, etc.

- Establishment of nationwide centers for medical genomics in at least one medical field (in the provision of services for personalized prevention, diagnostics, and treatment). Setting up a legislative and ethical framework for genomics and other OMICs methods.

- Legislative adjustments for biomedical research, which is currently not classified as healthcare under existing legislation (so-called preclinical research), requiring also ethical review adjustments for this type of biomedical research.

- Existing legislation regulating the sharing of epidemiological data.

- Systematic support for big data analysis in the use of information technologies in medicine, digitalization, and implementation of AI processes in clinical healthcare practice. Creation of standards for the use of these technologies, establishment of, for example, bioinformatics and AI laboratories, and continuous development of “data-driven healthcare.”

- Implementation of digital innovations in healthcare, e.g., mHealth tools in biomedicine, digital patient navigation tools in healthcare, digital tools for patient disease management.

- Implementation of digital tools, use of AI and machine learning tools for data processing.

- Building a biomedical and clinical research observatory platform (for systematic monitoring and evaluation of the use of the latest research findings to create and implement evidence-based policies and measures, also following the One Health principle, which will improve public health and reduce health inequalities).

- Updated educational programs for students and graduates in healthcare/biomedical fields linked to the needs of companies addressing global challenges in RDI in healthcare and biomedicine.

- Improving Slovakia's position as an innovator in biomedicine, biotechnology, and digital medicine (e.g., according to WIPO rankings, successful commercial cases realized).

- Slovakia's participation in ESFRI infrastructures for RDI (BBMRI, EATRIS, ELIXIR) and systematic continuous support for activities of national nodes (including ECRIN/SLOVACRIN), development and intensive collaboration with EMBL and other prestigious international research institutions, **European partnerships** implemented within Horizon Europe (HE), IPCEI including JPND and Brain Health.

4.2 Priority Area 4-2: New and Innovative Products, Processes, and Procedures in Healthcare

Transformational goal of the Priority Area 4-2

To introduce new and innovative products, processes, and procedures into (clinical) practice to improve the quality of life and healthcare services provided to citizens and patients in Slovakia. This goal can be supported by RDI projects focusing on specific areas such as prevention, diagnosis, treatment, follow-up care, or patient monitoring, with projects not necessarily needing to be comprehensive.

Current state of the Priority Area 4-2

- Slovakia achieves modest results in terms of its own healthcare innovations compared to other countries. In 2022, Slovakia ranked 28th out of 32 countries in the World Index of Healthcare Innovation (Czechia - 20th; Hungary - 29th; Poland - 32nd).[91]

- Slovakia lags significantly behind its potential, which is also reflected in the gradual decline of Slovakia's market share in clinical research.[92]

- Funding for RDI in medical and health sciences (which includes biomedical research) in Slovakia is at a low level, totaling 80.515 million EUR in 2022.[93]

- In Slovakia, support mainly persists only for basic and partially preclinical research.[94] There is a lack of knowledge regarding quality requirements for preclinical research so that these results can be usable for subsequent clinical research.

- There is an absence of linkage between the requirements for clinical research of various types of medical technologies for their approval for use in routine practice within the EU (registration of new medicines, certification of medical devices, etc., depending on the type of medical technology). Research and development based on direct demand from clinical practice is not conducted.

- Ineffective and unsystematic support for clinical research is also reflected in a low number of academic clinical studies[95] and a declining number of commercial clinical trials of medicines, a minimal number of clinical trials of medical devices and new technologies, including a minimal amount of clinical research focused on advanced therapy products.

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[91] FREOPP- World Index of Healthcare Innovation. Available at: https://freopp.org/slovakia-28-in-the-2022-world-index-of-healthcare-innovation/

[92] Healthcare Spending Review Update. Available at: https://www.mfsr.sk/files/archiv/94/Healthcare-Spending-Review-Update_ENG.pdf

[93] Eurostat. GERD by sector of performance and fields of R&D (2021). Available at: Statistics | Eurostat (europa.eu)

[94] APVV – Support for research and development projects in individual groups of science and technology fields (R&D). Available at: https://www.vedatechnika.sk/SK/VedaATechnikaVSR/odboryVaT/Stranky/default.aspx

[95] Zdravotnícke noviny – Organizational support for clinical trials and biomedical research in the Slovak Republic. Available at: https://www.mzsr.sk/Zdroje?/Sources/veda_vyskum_vyvoj/2019-09-zdn32_2019_07_2_ks_biomedicinsky_vyskum.pdf

- Insufficient support for the cooperation system between academic research and (clinical) practice.
- Presence of obstacles to a functional cooperation model between clinical practice, R&D institutions, and the business sector.
- Absence of activities for the assessment and evaluation of medical technologies by the NIHO institution (Act No. 358/2021), which currently focuses mainly on medicines.[96]
- Lack of an effective/flexible mechanism for financing innovations within the reimbursement system of health insurance companies (no innovation fund for biomedicine and health technologies).

Thematic Support Area in the Priority Area 4-2

Healthy Society	
Priority Area 4-2: New and Innovative Products, Processes, and Procedures in Healthcare	4.2.1. Research, development, and innovation of technologies for patient health monitoring
	4.2.2. Research, development, and innovation of diagnostic tools and their implementation into clinical practice
	4.2.3. Research, development, and innovation in materials for direct patient care[97]
	4.2.4. Research, development, and innovation in regenerative medicine, especially tissue engineering, cell and gene therapy
	4.2.5. Research, development, and innovation in 3D printing and 3D bioprinting with a focus on personalized treatment
	4.2.6. Research and development of medicines, drug forms, including supplements and personalized preparations

Target state of the Priority Area 4-2

- Creation of an interactive and regularly updated map of biomedical and clinical research and digital medicine, providing a clear overview of the steps needed for their successful implementation into (clinical) practice. The map covers the entire process, from initial research to long-term sustainability and international expansion, emphasizing the importance of expert collaboration, regulatory support, and continuous education.
- Introduction of new products, processes, and procedures in healthcare, and improvement of existing products, processes, and procedures used in (clinical) practice, together with appropriate legislative frameworks and reimbursement mechanisms.
- Optimization of comprehensive patient care management to improve treatment outcomes, increase efficiency and patient satisfaction, and optimize resource use.
- Implementation of prevention and early diagnostics tools into the healthcare system, including the introduction of telemedicine, in at least one priority area (oncology, neurology and cardiovascular system, rare, metabolic and infectious diseases).

[96] NIHO – National Institute for Health Technology Assessment. Available at: www.niho.sk
[97] By materials we mean nanomaterials, (bio)materials, etc.

- Strengthening the integration of digital technologies, enhancing interdisciplinary collaboration, improving communication with patients, and continuous education of healthcare personnel at least in priority areas (oncology, neurology, cardiovascular system, rare, metabolic, and infectious diseases).

- Strengthening intellectual property rights (IPR), including their exclusivity[98] and enforceability (e.g., measured by the number of licenses granted to third parties), and increasing IPR awareness within the community.

- Creation and implementation of a reimbursement innovation mechanism model aimed at accelerating the adoption of innovations into the reimbursement system of health insurance companies.

4.3 Priority Area 4-3: Breakthrough Technologies for Global Competitiveness[99]

Transformational goal of the Priority Area 4-3

Support for frontier RDI in medicine and related scientific fields, as well as innovative RDI projects in medical technologies with unique ideas that strengthen Slovakia's competitiveness as a global innovator. This means supporting projects in medical technologies — medicines, medical devices, methods, etc. — with high innovation potential and impact beyond Slovakia in all areas of healthcare. These projects do not need to be comprehensive; they can be specifically focused exclusively on prevention, diagnosis, therapy, or subsequent care, including patient monitoring, with a direct output into (clinical) practice.

Current state of the Priority Area 4-3

- Absence of global pharmaceutical/biotechnology RDI companies in Slovakia.

- In 2024, Slovakia ranked 24th in innovation potential among 27 EU countries. With innovation performance at 65.1% of the EU average, Slovakia is classified as an "emerging innovator."[100]

- Lack of grant and financial schemes in sufficient volumes to support the development of new products, processes, and procedures (including early high-risk development stages — potential inventions) in breakthrough technologies for global competitiveness in health. Such technologies are prerequisites for competitiveness growth, transformation, and the creation of new markets.

- National-level interventions aimed at supporting healthcare innovation through legislation and financial incentives are unsystematic and unpredictable.

- Lack of continuous support for the academic sector and clinical sphere in hospitals, start-ups/spin-offs, and shortage of expert knowledge in the necessary processes and procedures.

- Insufficient systemic support for academic clinical trials (co-financing from state sources) and limited options for supporting team education for clinical trials in healthcare facilities, including cooperation

[98] Exclusivity of intellectual property rights (IPR) means that the holder of these rights has the unique legal right to use their innovations according to applicable law, thereby protecting them from unauthorized use by third parties.
[99] Within the priority area, diverse R&D projects (including comprehensive and infrastructural projects) focused on prevention, diagnosis, and treatment with global significance will be supported, primarily in the areas of Mission Health – oncology, neurology, and the cardiovascular system, but also rare, metabolic, and infectious diseases.
[100] European Commission. European Innovation Scoreboard 2024. Available at: https://op.europa.eu/en/publication-detail/-/publication/8a4a4a1f-3e68-11ef-ab8f-01aa75ed71a1/language-en

with SLOVACRIN, National Oncology Institute (NOÚ), National Institute of Virology (NOI), Oncology Clinical Studies (OKS), etc., alongside the need for legislative adjustments.

- Clinical research in medical technologies in Slovakia is minimal. There is a very low number of academic clinical drug trials, a declining number of commercial clinical drug trials (without burden on health insurance companies), and a minimal number of clinical trials of medical devices.

Thematic Support Area in the Priority Area 4-3

Healthy Society	
Priority Area 4-3: Breakthrough Technologies for Global Competitiveness	4.3.1. Breakthrough research, development, and innovation in healthcare with export potential[101]

Target state of the Priority Area 4-3

- Created and supported ecosystem of innovation centers in hospitals based on collaboration among top experts from clinical practice, research, and industry, which supports RDI and subsequent commercialization of breakthrough technologies in the Slovak and foreign markets.

- Systematic preparation, creation, and support of grant schemes (including high-risk capital) targeting breakthrough RDI with potential to succeed in global markets.

- Effective increase in the share of joint RDI (cooperation of private and public sectors) with tangible practical results/outputs, including through Technology Research Centres (TRCs) specialized incubation programs run by industry experts.

- Strengthening and professionalization of technology transfer and cooperation in breakthrough technologies at national and international levels.

- Strengthening primary and secondary prevention in various therapeutic areas.

- Increased number of international, PCT patent applications in healthcare breakthrough technologies that proceed to regional (EP) or national phases (e.g., US, DE, UK) with subsequently granted patents aimed at strengthening exclusivity in relevant global markets.

- Higher number of academic clinical trials to enable access to innovative treatments prior to introduction of new technologies (medicines, medical devices, diagnostics, methods, etc.) into practice.

- Complex systemic support for the academic sector and clinical sphere in hospitals (including start-ups/spin-offs), emphasizing ensuring necessary expertise in processes and procedures.

[101] Breakthrough research also includes the creation and development of functional platforms, incubators, accelerators, and other areas for networking and clustering with the aim of supporting cutting-edge innovations, research, and development, especially in the fields of innovative therapies, medical technologies, tissue engineering in regenerative medicine, and diagnostic procedures and methods.

- Legislation supporting the development of academic clinical studies (A)CT, regulatory activities (State Institute for Drug Control - SÚKL, Ministry of Health of the Slovak Republic - MZ SR), and ethical oversight (Ethics Committee at MZ SR for evaluation of clinical trial projects of medicines and medical devices).

- Attracting excellent experts from abroad, including from the top 100 universities worldwide and industry, involved in innovation and research centers, also through specific grant schemes.[102]

Mission Health

A complementary output of the work of the Healthy Society domain is the strategic initiative **Mission Health**, focused on addressing the biggest challenges in healthcare in Slovakia. The concept of the Health Mission is part of Appendix 7.1.

Table 2: Essential Prerequisites for the Implementation of the Healthy Society

Name of the Prerequisite	Description of the Prerequisite
Systematic support for clusters, building and modernization of research and innovation centers, including "core facilities"	Innovations in healthcare are very difficult to apply within the existing healthcare infrastructure environment. In the previous programming period, Slovakia supported the construction of several science parks and centers fully focused on biomedical R&D. However, these workplaces were not provided with systematic development support and, due to the elimination of possibilities to draw resources from ESIF funds, they reached a state bordering on sustainability. Additionally, there is a disadvantage due to the impossibility of drawing capital funds within the Bratislava Self-Governing Region, which discriminates against a large group of researchers. Systematic support should stem from a planned interactive and regularly updated map of biomedical and clinical research and digital medicine, focusing on the creation of clusters linking research centers/university faculties/hospitals or specialized healthcare workplaces with small, medium, and large enterprises. It is necessary to simultaneously strengthen personnel capacity at an appropriate level and support the development of joint R&D, contractual R&D, or services in biomedical R&D and its internationalization.
Systematic support for the development of innovative SMEs, including start-ups and spin-offs in healthcare	Initial financial support is key, especially for emerging innovative companies. Financial incentives for SMEs are currently significantly underdimensioned; therefore, it is necessary to implement systematic continuous grant schemes aimed at improving the commercial utilization of RDI results in healthcare.
Strengthening the protection of intellectual property rights and technology transfer in healthcare	Although interest in intellectual property (IP) protection is gradually increasing in Slovakia, most stakeholders indicate low awareness of IP protection, which reflects Slovakia's position as an "emerging" innovator. It is therefore essential to improve the current weak "IP

[102] For example, the call "Support for Excellent Research Teams" within the "Operational Programme Research, Development and Education." Available at: https://opvvv.msmt.cz/vyzva/copy-vyzva-c-02-15-003-podpora-excelentnich-vyzkumnych-tymu/text-vyzvy.htm.

	awareness" by strengthening IP protection and effective technology transfer through targeted projects and collaboration with the scientific community via organizations focused on innovation support, including incubators/accelerators, hubs, clusters, and platforms like TRC—a specialized incubation program operated by industry experts that would specifically focus on innovations in life sciences/medical sciences and breakthrough technologies. In this context, the Act on the Slovak Academy of Sciences (transformation into public research institutions) and legal norm adjustments, including the upcoming law supporting research, development, innovation, and technology transfer, play an important role.
Creation of an innovation fund for RDI in healthcare with mandatory participation of health insurance companies and involvement of other entities	Amendment of the law on state reporting and records for the field of RDI in healthcare.
Support for coverage and reimbursement mechanisms	Access to technological innovations and new trends in healthcare provision in Slovakia is limited. It is essential to change the view and attitude of the state and health insurance companies toward determining necessary diagnostic and therapeutic options for patients based on innovation management and the introduction of new, innovative products and services into the healthcare provision system.

Food Competitiveness and Climate Resilience

5. Food Competitiveness and Climate Resilience

The goal of the Food Competitiveness and Climate Resilience domain is:

- Catch up with global development, increase the interconnection of practice in RDI, and address the weak diversification of the Slovak economy.
- Support value creation for primary producers and processors of agricultural raw materials through the implementation of RDI results and the introduction of innovations.
- Strengthen the food and agro-sector in RDI, focusing on the use of AI, robotics, and digitalization.
- Enhance support for research, development, and innovation as a tool to achieve food security and strengthen critical infrastructure.
- Create conditions for the utilization of waste in the food chain and secondary processing of waste from food production and by-product processing.
- Apply innovative solutions for sustainable biosystems and biotechnologies, biomass production systems, and innovative solutions for implementing circular bioeconomy.
- Address and support innovative solutions for biodiversity management in the context of the climate change impacts and respond to challenges related to global megatrends, such as the sustainability of current land use.
- Support the construction of green infrastructure to reduce the impacts of climate change on agricultural and forest landscapes.
- Implement measures to halt biodiversity loss and increase the sustainability of managing available genetic resources.
- Prepare models and tools to manage threats such as pandemics, infectious diseases, natural risks, or impacts of climate change.
- Ensure sustainable management of soil and water to maintain the quality and quantity of biomass. Implement solutions for sustainable biomass management, considering key indicators of soil and water health in the production of primary biomass and its impact on the circular bio-based value chain.
- Support and utilize the potential of existing structures, capacities, and RDI projects of institutions with sufficient expertise and excellence in the field and increase their participation in joint projects.
- Support and implement AKIS (Agricultural Knowledge and Innovation Systems) and improve the insufficient transfer of knowledge into practice, the level of investments, and the status of venture capital in science and research activities in the sector.
- Support the creation and functioning of EIP Operational Groups, thereby connecting research, development, and practice in areas focused on primary production and processing of agricultural products and forestry.
- Strengthen and build a comprehensive system of knowledge transfer, further advisory services, and education in agriculture, and support the involvement of universities and research institutes in applied agricultural research and further advisory and educational services with reflection on new topics.
- Strengthen international cooperation within the BioEast initiative aimed at implementing innovations in bioeconomy and circular economy.
- Integrate the research tool of living labs into practice across all priority areas and support research infrastructures and sharing of research infrastructure for the entire ecosystem.
- Build at least 4 living labs by 2030.[103]

[103] Map of Living Labs and Lighthouses. Available at: https://prepsoil.eu/living-labs-and-lighthouses/map.

- Support stakeholders in the domain to increase participation in the European Research Area, especially in the Horizon Europe (HE) program, innovation programs, and other supporting tools.
- Support and implement EU Missions as a research and innovation instrument within the HE programs in Slovakia.
- Support research, development, and implementation of technologies defined in STEP (Strategic Technologies for Europe Platform) and in line with the goals of this domain.

5.1 Priority Area 5-1: Food Competitiveness and Resilience

Transformational goal of the Priority Area 5-1

Create and strengthen an innovative environment to increase the competitiveness of primary producers, food manufacturers, and processors of agricultural raw materials; support lagging technological development and innovation performance. Reduce the negative balance of foreign trade and create conditions for the utilization of waste in the food chain, secondary processing of waste from primary production and food manufacturing, and processing of by-products.

Current state of the Priority Area 5-1

- **Agriculture in Slovakia shows low added value (per hectare of land).** This situation results from the structure of agricultural production, dominated by low value-added products (cereals and oilseeds). There is a long-term trend of decline in livestock production and specialized crop production (fruits and vegetables), negatively affecting added value in this sector.[104] The absence of vertical structures in the agro-food chain leads to decreased food security in Slovakia and lower added value from production.[105]

- **Slovakia is among the countries with the lowest RDI expenditures per capita in agriculture (statistics for 2013-2021).**[106]

- **Insufficient implementation of project measures aimed at active collaboration (multi-actor approach)** between RDI actors and practice in the Rural Development Program measures (EIP OG - European Innovation Partnership Operational Groups).

- **Delayed and fragmented development of the AKIS system,** which should not function only on an institutional basis.

- **The advisory system for the food industry is underdeveloped**, limiting the flexible introduction of innovations into food production and insufficiently linking research institutions with food industry practice.

[104] Value for Money: Review of Agriculture and Rural Development Expenditure, Final Report, HM Treasury. Available at: https://www.mfsr.sk/files/archiv/1/Vlastny_mat_Zaverecna_sprava_revizie_vydavkov_final.pdf
[105] Ministry of Agriculture of the Slovak Republic: Report on Agriculture and Food Industry in the Slovak Republic for the Year 2022. Available at: https://www.mpsr.sk/download.php?fID=24302
[106] European Commission: GERD by sector of performance and fields of R&D. Agricultural sciences. Available at: https://ec.europa.eu/eurostat/databrowser/view/rd_e_gerdsc__custom_10709643/default/table?lang=en

- **Insufficient use of the Living Labs tool in practice.**[107]

- Compared to other EU countries, Slovakia's yield per hectare is average or below average. **Slovakia has a negative foreign trade balance with EU member states, which may indicate problems with the competitiveness of the Slovak agri-food sector compared to EU member states.** [108] Reduced competitiveness of the Slovak agri-sector is also reflected in the presence of Slovak products in retail.[109] The share of Slovak and private label products displayed in retail (based on 2023 data) indicates weak representation of domestic products in retail. Statistically, only 41.7% of agri-sector products in retail in 2023 were Slovak. [110]

- **Currently, direct sales from farms represent a low percentage of agricultural production**, highlighting the need to increase support and improve conditions for the development of these value and production chains. Within the framework of EU rules, it is necessary to establish fair relationships between the various links of the food vertical, primarily strengthening the market bargaining power of primary producers and food manufacturers within the food vertical.

- **The agro-sector shows weak national support for research in the agri-food sector**, with necessary research activities insufficiently supported.

- **There is an absence of more flexible and less bureaucratic procedures in the new programming period 2021-2027 for supporting innovations** and implementing best practices.

- **Expenditures on RDI in agricultural sciences in 2021 accounted for only 0.03% of GDP, placing Slovakia among the EU countries with low investments in this area. It is also noted that agriculture and forestry represent only 2.2% of GDP and 3.3% of RDI investments.** Slovakia has significant potential to implement innovative production processes in several sectors such as robotics, green transformation, and bioeconomy.[111]

- **Insufficient incentives to maximize circularity opportunities, both at the beginning and end of the value chain.** Existing policy frameworks do not contribute to policy synergies that strengthen tools aimed at product design, increase demand for resource-efficient products, and promote more efficient resource use in production processes and new circular business models. **The potential of bioeconomy sectors is politically underestimated.** [112]

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[107] European Commission: Horizon Europe Work Programme 2023-2024. Available at: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/cluster-6-food-bioeconomy-natural-resources-agriculture-and-environment_en

[108] Import and export of agricultural and food products for the years 2022 and 2023 (in million EUR). Own processing by the working group.

[109] Results of the survey on the exposure of Slovak products on retail shelves for the year 2023, conducted by the agency Go4Insight. Own processing by the working group.

[110] Ministry of Agriculture of the Slovak Republic: Report on Agriculture and Food Industry in the Slovak Republic for the Year 2022. Available at: https://www.mpsr.sk/download.php?fID=24302

[111] EIT: Food Foresight: Impact of COVID-19 on the agri-food sector in Central and Eastern Europe. Available at: https://www.eitfood.eu/projects/food-foresight

[112] Ministry of Investments, Regional Development and Informatization of the Slovak Republic: Supporting the Transformation of the Slovak Economy by Increasing Its Innovation Performance 2020. Available at: https://mirri.gov.sk/wp-content/uploads/2021/03/RTDI-in-Slovakia-AS-IS-report.pdf

- **Insufficient implementation of innovations in robotics and digitalization, and delayed response to current technological trends and consumer preferences,** negatively impacting the sustainability of the agri-food sector.

- **Compared to the average of Central and Eastern Europe, food production in Slovakia is vulnerable to disruptions in global value chains due to high imports.** A significant role in this process is played by adequate and timely preparation for more structural changes affecting the sector, including climate change and stricter environmental regulations. This highlights the need to integrate green policies into national policies to support sustainable and innovative local food systems.[113]

- Insufficient financial support for food producers within the Common Agricultural Policy, where food producers are eligible applicants, leads to limited opportunities for innovation creation in the food industry.[114] **The total financial support to Slovak agriculture decreased by 7.5% year-on-year to €737 million, of which 57% was provided from EU sources. The share of total support to agricultural revenues declined year-on-year to 17.5%, with direct payments accounting for 6.6%.**

Thematic Support Area in the Priority Area 5-1

Food Competitiveness and Climate Resilience	
Priority Area 5-1: Food Competitiveness and Resilience	5.1.1. Innovations in the Food Industry[115]
	5.1.2. Utilization of Waste in the Food Chain and Secondary Processing of Waste from Food Production and By-Product Processing

Target state of the Priority Area 5-1

- **Fully functional vertical structures** creating conditions **for increasing the added value of food primary producers** and improving Slovakia's food security.

- **Positive trade balance in food products**, increased share of Slovak-produced food on retail shelves, and higher competitiveness of the Slovak agri-food sector.

- **Traditional linear food systems transformed into circular systems.**

- **Higher degree of utilization of AI, robotics, and digitalization in RDI projects in the food industry.**

- **Innovative solutions in primary production,** in the Slovak food and processing chain**, more efficient bio-waste chains, circular systems in primary production and processing.**

[113] EIT: Food Foresight: Impact of COVID-19 on the agri-food sector in Central and Eastern Europe. Available at: https://www.eitfood.eu/projects/food-foresight
[114] Ministry of Agriculture of the Slovak Republic: Report on Agriculture and Food Industry in the Slovak Republic for the Year 2022. Available at: https://www.mpsr.sk/zelena-sprava/121
[115] Innovation in the food industry involves the introduction of new or significantly improved products, processes, or technologies that enhance the efficiency, safety, and sustainability of food production. This includes biotechnology, innovative methods of food preservation and packaging, as well as the implementation of digital technologies such as sensor systems or artificial intelligence.

- **Implemented solutions to key issues for preserving production capacity** and "land consumption" in food production, high water and energy consumption, reduction of harmful greenhouse gas emissions and pollutants, etc.

- Marketing associations, clusters, unions, federations, organizations, and associations of cooperating actors, farmers, food producers, and companies**—implement innovative solutions to increase domestic sales, technological and process innovations, innovations leading to higher finalization of local production, innovative marketing models, and social innovations.**

- **Higher added value of primary producers and processors and higher engagement in innovations,** strengthening their competitiveness.

- **More intensive and efficient use of waste in the food chain and secondary processing of waste from** food production and by-product processing.

- Creation and effective sharing of databases in the agriculture, food, and forestry sectors and subsequently qualified decision-making based on existing databases.

- **Innovative models and tools to manage societal threats** such as pandemics, infectious diseases, natural risks, or impacts of climate change.

- **Increased quality and availability of human capital and higher engagement of** RDI actors in the sector in joint projects in the area.

- **An effective and functional AKIS system as well as advisory services for NOVEL FOOD** for agriculture and food production that respond to sector needs and contribute to improving and strengthening RDI.

- **Integration of the living labs research tool** (including sharing research infrastructure across the entire ecosystem) into practice within the thematic area of RDI support.

- Engagement and support of public and private research and innovation actors from Slovakia in major **international partnerships to support infrastructure sharing, data** (ESFRI), **and European partnerships** (such as CBE JU and EIT Food).

5.2 Priority Area 5-2: Circular Production Systems Based on Biomass

Transformational goal of the Priority Area 5-2

Support innovative solutions for sustainable biosystems and biotechnologies, biomass production systems, and innovative solutions for the implementation of circular bioeconomy, ensuring long-term sustainable biomass-based production sectors. At the same time, ensure sustainable management of soil and water to maintain the quality and quantity of biomass.

Current state of the Priority Area 5-2

- **Current water and soil use in the country negatively impacts the maintenance of biomass quality and quantity.** Insufficient sustainable biomass management, as a key indicator emphasizing significant

factors such as soil and water health in primary biomass production, adversely affects the circular economy value chain and biological materials. **Slovakia has not yet effectively adopted the EU's ambitions towards a carbon-neutral future and recognition of the important role of the bioeconomy in achieving climate neutrality and environmental sustainability.**[116]

- **Slovakia still does not aim to secure the long-term sustainability of biomass-based production sectors.** The sustainability of food and agricultural systems is threatened due to unsustainable use of biomass and waste, as well as climate change threats.[117]

- Apart from biomass-based systems, **Slovakia has a worsening trade deficit dependent on the import of food production.** This situation is related, for example, to inefficiencies (or sustainability challenges) in production systems.[118]

- **The approach to biomass-based economy through linear models and bioproducts together with food systems in Slovakia represents an unsustainable system (mainly due to complex economic, social, and environmental components of the food chain).** Biomass production and processing in Slovakia are largely based on linear models with the ambition to gradually transition to circular ones.[119]

- **For the proper setup of the bio-waste valorization system, high-quality and publicly available information on sources of bio-waste and biomass is lacking.**[120]

- **The low utilization rate of biomass potential in Slovakia limits achieving higher added value of biomass-based production,** as confirmed by research comparing Central and Eastern European countries.[121] The research points to a deficit in efficient use of agricultural sector waste. **Agriculture remains a sector with low labor productivity, highlighting the importance of innovation and biomass utilization for higher-value products to improve sector productivity.**[122]

- **Slovakia does not fully utilize biomass potential that could provide higher added value in the bioeconomy.**[123] Biomass in Slovakia is mainly used for food and non-food purposes, with approximately one-third of all extracted or produced materials being biomass. Biomass production is characterized by low valorization and processing, indicating underutilization of its potential. Basic raw material from land produced in Slovakia is poorly valued, with a dominance of exports of unprocessed biomaterials. There is a huge untapped potential for more efficient use of biomass flows.[124]

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[116] BIOEAST: *Bioeast Foresight Exercise: Sustainable Bioeconomies towards 2050.* Available at: https://bioeast.eu/wp-content/uploads/2021/10/BIOeast-Report-2021_FINAL_compressed-1.pdf
[117] BIOEAST: *Strategic concept paper For Bioeconomy_Slovakia.* Available at: https://bioeast.eu/wp-content/uploads/2019/10/SK-concept-paper-summary.pdf
[118] Import and export of agricultural and food products for the years 2022 and 2023 (in million EUR). Own processing by the working group.
[119] BIOEAST: *Bioeast Foresight Exercise: Sustainable Bioeconomies towards 2050.* Available at: *https://bioeast.eu/wp-content/uploads/2021/10/BIOeast-Report-2021_FINAL_compressed-1.pdf*
[120] RePowerEU. Available at: https://www.planobnovy.sk/site/assets/files/3330/repowereu.pdf (p. 16)
[121] Vlad, Ionela; Toma, Elena: *Bioeconomy and Biomass Sectors in Central and Eastern European Countries*. Available at: https://www.mdpi.com/2073-4395/12/4/880
[122] Nowak, Anna; Kobialka, Anna; Krukowski Artur: *Significance of Agriculture for Bioeconomy in the Member States of the European Union*. Available at: https://www.mdpi.com/2071-1050/14/1/60
[123] BIOEAST: *Bioeast Foresight Exercise: Sustainable Bioeconomies towards 2050.* Available at: https://bioeast.eu/wp-content/uploads/2021/10/BIOeast-Report-2021_FINAL_compressed-1.pdf
[124] BIOEAST: *Strategic concept paper For Bioeconomy_Slovakia.* Available at: https://bioeast.eu/wp-content/uploads/2019/10/SK-concept-paper-summary.pdf

- Larger farms (over 50 hectares) make up about 15-20% of all farms but already manage a significant share of agricultural land, around 60-70% of the country's total agricultural land. Economic pressures have led, similarly to the EU, to an increase in specialized farms and a sharp decline in farms with livestock production.[125]

- Slovakia faces challenges in diverting food waste and other bio-waste from landfills, with a significant portion of municipal waste still ending up in landfills compared to the EU average.[126] **The underutilized biomass potential in Slovakia is also confirmed by a lower recycling rate of municipal waste expressed in percentage. In 2022, Slovakia recycled 49.5% of municipal waste, which is above the EU average of 48.6%.**[127]

- **The use of composting and anaerobic digestion systems, which are key for closing the biological cycle of bio-waste in the agricultural sector, is underdeveloped in Slovakia.** Many biogas plants focus on electricity production with suboptimal heat utilization and without using biodegradable waste (typically using maize silage). This points to insufficient use of closed-cycle biomass systems on farms.[28]

- Slovakia is characterized by a weak position of primary producers in the value chain. **The need to improve living standards in rural areas limits attracting young people, indirectly indicating the current vulnerability and potentially weak position of primary producers.** The added value of primary agricultural production in Slovakia is lower than the EU average, indicating a gap in value capture by primary producers.[128]

- **The potential for implementing a circular bioeconomy and strengthening the value chain can be seen, for example, in the production and manufacturing of organic fertilizers.**[129] Domestic processing of wood assortments achieves low added value. The Slovak wood-processing industry also has greater potential for cascading wood processing and its circular use. Slovakia also lacks sufficient capacities to produce higher value-added wood products (especially in veneers, fiberboard, OSB, packaging, and special paper).[130, 131]

- **The current level of cooperation between the public and private sectors in Slovakia** (including government agencies) is limited, especially in the context of the transition to a circular economy. [132] Slovakia also suffers from insufficient sectoral and inter-sectoral coordination.[133]

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[125] Ministry of Agriculture and Rural Development: Review of expenditure on agriculture and rural development - Interim report. Available at: https://www.mpsr.sk/institut-podohospodarskej-politiky/1263-184-1263/?year=2021
[126] OECD: *Closing the loop in the Slovak Republic. A roadmap towards circularity for competitiveness, eco-innovation and sustainability.* Available at: https://www.oecd-ilibrary.org/environment/closing-the-loop-in-the-slovak-republic_acadd43a-en
[127] Enviroportal of the Ministry of Environment of the Slovak Republic – Municipal Waste Recycling Rate 2022. Available at: https://www.enviroportal.sk/indicator/detail?id=3501
[128] BIOEAST: *Strategic concept paper For Bioeconomy_Slovakia.* Available at: https://bioeast.eu/wp-content/uploads/2019/10/SK-concept-paper-summary.pdf
[129] Justification of the needs of state government intervention in agroforestry systems in abandoned agricultural land in Slovakia. Own processing by the working group.
[130] Ministry of Agriculture and Rural Development of the Slovak Republic: Report on Forestry in the Slovak Republic for the Year 2022. Available at: https://www.mpsr.sk/zelena-sprava-2023/123---19005/
[131] Woodworking Magazine: The Woodworking Dilemma Hits Hard. Available at: : https://drevmag.com/2024/03/07/drevarska-dilema-dolieha
[132] OECD: *Closing the loop in the Slovak Republic. A roadmap towards circularity for competitiveness, eco-innovation and sustainability.* Available at: https://www.oecd-ilibrary.org/docserver/acadd43a-en.pdf?expires=1721035647&id=id&accname=guest&checksum=BBEBCC2EB31253627C88665ACA764C29
[133] BIOEAST: *Bioeast Foresight Exercise: Sustainable Bioeconomies towards 2050.* Available at*: https://bioeast.eu/wp-content/uploads/2021/10/BIOeast-Report-2021_FINAL_compressed-1.pdf*

Thematic Support Area in the Priority Area 5-2

Food Competitiveness and Climate Resilience	
Priority Area 5-2: Circular Production Systems Based on Biomass	5.2.1. Innovative solutions for the implementation of circular bioeconomy
	5.2.2. Innovative solutions for sustainable biosystems, biotechnologies, and biomass production systems

Target state of the Priority Area 5-2

- **Increased utilization of biomass potential in Slovakia.**
- **Application of innovative solutions for sustainable biosystems and biotechnologies,** innovative solutions for implementing **circular bioeconomy,** and functional and long-term **sustainable biomass production systems.**
- **Innovative biodiversity management solutions** related to the impact of climate change, capable of responding to challenges associated with global megatrends such as the sustainability of current land use.
- **Sustainable systems for soil and water management** aimed at maintaining the quality and quantity of biomass – innovative solutions to increase the sustainability of biomass management based on key indicators such as soil and water health in primary biomass production and its impact on the circular bio-based value chain.[134]
- **Higher utilization of composting and anaerobic digestion systems.**
- **Innovative solutions contributing to fulfilling international commitments and ambitions towards a carbon-neutral future** and recognizing the important role of the bioeconomy in achieving climate neutrality and environmental sustainability.
- **Applied solutions and innovative approaches for the transition of linear food systems** to circular systems in the food industry and bioeconomy.
- **Greening the economy through circular bioeconomy and strengthening the local value chain.**
- **Implemented innovative solutions for the Slovak food and bio-waste chain** (e.g., solutions for the national circular bioeconomy – addressing high consumption of land, water, and energy, and large production of potential greenhouse gas emissions).
- **Increased use of AI, robotics, and digitization in RDI projects.**
- **Strengthened resilience to multiple risks, innovative models and tools to manage societal threats** such as pandemics, infectious diseases, natural risks, or the impacts of climate change.

[134] The circular bio-based value chain is built on three fundamental pillars: Developing an evaluation framework for implementing circularity within three biological value chains. Creating a linkage between circularity strategies and the level of technological readiness (TRL) in bio value chains. Mapping value chains and identifying key actors from raw material utilization to end-of-life management.

- **An efficient and functional AKIS system** that responds to agricultural needs and contributes to improving and strengthening RDI.

- **Higher quality and availability of human capital and increased involvement of RDI actors** in the sector in joint projects in the given area.

- **Involvement and support of public and private research and innovation actors from Slovakia in significant international partnerships to promote sharing of infrastructure, data (ESFRI), and European partnerships (such as CBE JU and EIT Food).**

- **Integrated research tool of living labs** (including sharing research infrastructure across the entire ecosystem) into practice within the scope of the thematic RDI support area.

- **Strengthened value chain in the production and manufacturing of organic fertilizers.**

5.3 Priority Area 5-3: Building Green Infrastructure and (Current) Sustainable Land Use

Transformational goal of the Priority Area 5-3

To introduce and support innovative approaches in biodiversity management related to climate change, capable of addressing challenges associated with global megatrends such as the sustainability of current land use. To utilize resources and nature with an emphasis on reducing environmental burdens and sustainability while increasing competitive advantages. At the same time, to support the development of green infrastructure aimed at reducing the impacts of climate change on agricultural and forest landscapes.

Current state of the Priority Area 5-3

- **Slovakia is among the countries experiencing significant soil degradation due to the absence of a national soil management system. This results in a substantial loss of the soil's ability to provide ecological functions for various forms of life.**[135] Unsustainable land use due to intensive agricultural practices negatively affects soil biodiversity. This leads to various forms of soil degradation such as loss of organic carbon, pollution, compaction, and erosion. These practices adversely impact soil organism habitats and overall soil health.[136] Problems related to unsustainable land use cause consequences of intensive agriculture in rural and natural areas of the country.[137]

- **Approximately 75% of species and 60% of habitats in Slovakia are in poor or unsatisfactory condition**, caused by pressures such as unsustainable agricultural practices, infrastructure development, invasive non-native species, or other problematic “native” species. The costs of lost ecosystem services due to ecosystem degradation are estimated at 20 billion euros annually. Key pressures on biodiversity include unsustainable agricultural practices; invasive non-native species and other problematic native species; habitat fragmentation and soil compaction mainly through development of residential,

[135] European Commission: *European Commission on Agriculture (2023).* Available at: https://openknowledge.fao.org/server/api/core/bitstreams/7313e713-0b50-482b-ac45-a4e1004f9861/content
[136] BIOEAST: *Bioeast Foresight Exercise: Sustainable Bioeconomies towards 2050.* Available at: https://bioeast.eu/wp-content/uploads/2021/10/BIOeast-Report-2021_FINAL_compressed-1.pdf .
[137] Enviroportal*: Nature Outlook 2050 Slovakia.* Available at: https://www.enviroportal.sk/dokument/f/nature-outlook-2050

commercial, industrial, and transport infrastructure; and natural processes such as secondary ecological succession.[138,139]

- Slovakia faces challenges related to inter-ministerial coordination in creating and implementing policies in the bioeconomy. **Insufficient coordination hinders a holistic approach to natural resource management and sustainable agricultural development.**[140]

- **It is estimated that prices of basic foods in Slovakia will increase approximately twice as fast as predicted in 2006** due to climate change, with significant impacts on the environment and food security.[141]

- **Research conducted in Slovakia demonstrates ongoing unsustainable pressure on nature and resources.** Conflicts and clashes of interest exist between economic sectors and nature conservation, especially in urban areas. Research also points to the neglect of ecosystems and natural resource protection during urbanization in Slovakia. This causes multiple landscape, ecological, and environmental problems. Many natural ecosystems have been occupied and degraded, shares of green infrastructure elements have been reduced, the degree of anthropization of the territory has increased, and a significant portion of the best soils has been built over.[142] **Slovakia continues to face high levels of air pollution, inadequate waste management with landfill disposal, and unsustainable agricultural practices.**[143]

- **There is a need to implement the Integrated National Energy and Climate Plan (NECP) for 2021–2030** and the Low-Carbon Development Strategy until 2030 with a view to 2050, to contribute to achieving the EU's energy and climate targets for 2030 and to reach carbon neutrality by 2050.

- Slovakia is actively engaged in increasing demand for more environmentally friendly approaches to processes, more efficient resource use, circular economy, and monitoring and reducing carbon footprint. **The food system is a priority area for the national circular bioeconomy due to its high consumption of land, water, and energy. It also produces significant potential greenhouse gas emissions. A wide range of measures still needs to be implemented in the Slovak food and bio-waste chain.**[144]

- **Slovakia's environmental policy strategy until 2030 emphasizes the importance of better utilization of accurate and up-to-date data in developing effective measures and policies.**

- The impacts of climate change in Slovakia mainly manifest as extreme heatwaves and frequent heavy rains causing floods. **Flood damage is several times higher than investments in flood protection. Over the**

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[138] State Nature Conservancy of the Slovak Republic: *Conservation status of hatitats and species of Community interest in the period 2013-2018 in the Slovak Republic*. Available at: https://www.sopsr.sk/natura/dokumenty/Monografia_reporting_art17_2013_2018.pdf
[139] Lazíková, Jarmila; Banlerová, Anna; Lazíková, Zuzana: *Legislation on land protection in Slovakia*. Available at: https://real.mtak.hu/111247/1/170-Article%20Text-619-1-10-20200612.pdf
[140] BIOEAST: *Bioeast Foresight Exercise: Sustainable Bioeconomies towards 2050.* Available at: https://bioeast.eu/wp-content/uploads/2021/10/BIOeast-Report-2021_FINAL_compressed-1.pdf .
[141] Holúbek, Ivan; Tóth, Marián; Jakabovičová, Johana: *Financing climate change in the conditions of the Slovak agricultural sector.* Available at: https://www.shs-conferences.org/articles/shsconf/pdf/2021/03/shsconf_glob20_02021.pdf
[142] Izakovičová, Zita; Petrovič, František; Pauditšová, Eva: *The Impacts of Urbanisation on Landscape and Environment: The Case of Slovakia*. Available at: https://www.mdpi.com/2071-1050/14/1/60
[143] OECD: *Environmental Performance Reviews Slovakia 2024 report*. Available at: https://www.oecd.org/slovakia/oecd-environmental-performance-reviews-slovak-republic-2024-108238e8-en.htm
[144] OECD: *Closing the loop in the Slovak Republic. A roadmap towards circularity for competitiveness, eco-innovation and sustainability.* Available at: https://www.oecd-ilibrary.org/docserver/acadd43a-en.pdf?expires=1721035647&id=id&accname=guest&checksum=BBEBCC2EB31253627C88665ACA764C29

last 20 years, the average annual flood damage in Slovakia was approximately 70 million euros, with the highest in 2010 when damages and rescue costs exceeded half a billion euros. State policy does not take climate change consequences seriously enough, resulting in insufficient innovation and research support.

- **Slovakia currently ranks 21st within the EU-27 in the Eco-innovation Index.** Slovakia struggles to secure funding for RDI in biodiversity. While the Ministry of Environment of the Slovak Republic (MŽP SR) joined the European partnership Biodiversa+ in 2020, Slovakia has yet to fully utilize this partnership's potential to support RDI.[145] **Slovakia performs weakest among eco-innovation indicators related to eco-innovation patents and government R&D funding in the environment and energy sectors.**[146]

- **Currently, living labs are still insufficiently supported in RDI.**[147] Slovakia does not appear on the "European Network of Living Labs" map, indicating non-participation, likely due to a lack of systematic support and their low number.[148]

Thematic Support Area in the Priority Area 5-3

Competitiveness and Climate Resilience	
Priority Area 5-3: Building Green Infrastructure[149] and (Current) Sustainable Land Use	5.3.3. Building green infrastructure, impacts of climate change on agricultural and forest land

Target state of the Priority Area 5-3

- **Sustainable land** use and preparedness for challenges associated with global megatrends.

- **Reduced impacts of climate change on agricultural and forest land** and strengthened development of green infrastructure.

- **Innovative approaches to stop biodiversity loss** and increasing sustainability in the management of available genetic resources through RDI.

- **Innovative models and tools to manage societal threats** such as pandemics, infectious diseases, natural hazards, impacts of climate change, or the spread of invasive species.

- **Improvement in the Eco-Innovation Index** from 21st place to 15th place by 2030.

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[145] OECD: *Environmental Performance Reviews Slovakia 2024 report*. Available at: https://www.oecd.org/slovakia/oecd-environmental-performance-reviews-slovak-republic-2024-108238e8-en.htm

[146] Eco-Innovation Country Profile 2022: Slovakia Available at: https://circabc.europa.eu/ui/group/96ccdecd-11b4-4a35-a046-30e01459ea9e/library/7ec3d9d9-99ba-4a9b-8ffe-7368a2641ded/details

[147] BIOEAST: *Bioeast Foresight Exercise: Sustainable Bioeconomies towards 2050.* Available at*: https://bioeast.eu/wp-content/uploads/2021/10/BIOeast-Report-2021_FINAL_compressed-1.pdf.*

[148] European network of Living Labs. Available at: https://enoll.org/network/living-labs/?livinglab=living-lab-tomsk-network#description

[149] Green infrastructure includes a network of natural and semi-natural areas that provide ecosystem services such as water purification, surface water retention, and air quality improvement. In agricultural and forest landscapes, it serves to protect biodiversity and support ecological stability.

- **Development of a methodology for the implementation and management of eco-innovations** in Slovakia, primarily to strengthen the lack of eco-innovation in Slovak companies.
- **Sustainable soil and water management** regarding maintaining the quality and quantity of biomass.
- **Elimination of unsustainable management practices** that lead to soil degradation (loss of organic carbon, inappropriate soil technological operations, pollution, compaction, and erosion).
- **A holistic approach to managing natural resources** and sustainable development of land management.
- **Innovative solutions that contribute to fulfilling international commitments and ambitions for achieving carbon neutrality** by 2050 and the EU's energy and climate targets.
- **Innovative solutions to reduce air pollution, insufficient waste management** (waste ending in landfills), and the use of inappropriate agricultural practices.
- **Higher use of AI, robotics, and digitalization in solving RDI projects.**
- **An efficient and functional AKIS system** that responds to sector needs and contributes to the improvement and strengthening of RDI.
- **Higher quality and availability of human capital and increased involvement of RDI actors** in sector joint projects.
- **Integration of the living labs** research tool (including shared research infrastructure across the entire ecosystem**) into practice within the scope of the thematic support area.**
- **Implementation of documents such as the Integrated National Energy and Climate Plan for 2021–2030** (NECP) and the Low-Carbon Development Strategy until 2030 with a view to 2050.

5.4 Priority Area 5-4: Biodiversity Management and Climate Change Adaptation

Transformational goal of the Priority Area 5-4

Improve land management in the context of climate change to protect soil and water resources and **implement measures for climate change adaptation**. Develop solutions for environmental problems that directly impact environmental quality and health, air quality, waste **management**, pollution prevention, and their effects on public health.

Current state of the Priority Area 5-4

- **Addressing the current state of biodiversity protection, sustainable land use, and climate change mitigation represents a key challenge for Slovakia in the coming years.** The impacts of climate change increase the need to tackle biodiversity issues in Slovakia, such as declines in certain species and habitats, continued integration of various approaches to biodiversity protection into sectoral policies including forestry, and consideration of climate change impacts.
- **Resource productivity in Slovakia does not reach the EU average.** Resource use and nature management in Slovakia still fall short of the desired state, as key challenges are not directly related to

extraction and management of natural resources.

- **Challenges have been identified in Slovakia regarding the implementation of landscape-ecological documentation within spatial planning processes.** [150] Slovakia needs to support eco-design, eco-innovations, and the use of secondary raw materials in production to enable citizens to become more ecological and improve material recycling.[151]

- **Forest and agricultural landscapes in Slovakia are insufficiently adapted to the consequences of climate change, which may lead to negative impacts on soil quality and water resources.**[152]

- **Slovakia faces unresolved environmental issues that can negatively affect environmental quality and health.**[153] The Environmental Policy Strategy of Slovakia until 2030 recognizes the importance of addressing environmental problems to improve overall quality of life and protect public health.

- In Slovakia, production systems face risks caused by various threats (spread of plant diseases, invasive species, low resilience of new crop varieties and breeds). Slovakia insufficiently utilizes methods to increase agricultural productivity that would help recognize and mitigate these risks. The vulnerability of Slovak agriculture is also caused by the susceptibility of certain crops to diseases or invasive species. **The impacts of climate change result in longer droughts as well as heavy rains, strong winds, and soil erosion, which can affect soil quality and crop production.** These factors pose risks to agricultural production systems in Slovakia.[154]

- **Biodiversity protection is crucial in Slovak agriculture, especially concerning native plant species and domestic breeds of farm animals.** Many species of plants and animals in Slovakia are endangered. According to the Red List, nearly one-quarter of Slovak vertebrates are threatened, including 44% of amphibians, 42% of reptiles, and 24% of birds. About 7% of nearly 25,000 known invertebrate species in Slovakia face extinction. Nearly 12% of non-vascular plants and 15% of vascular plants are endangered. Among plants, mosses stand out, with 45% of the 699 known species in Slovakia being threatened.[155]

- **In the context of Slovakia's Environmental Policy Strategy until 2030, there is insufficient support for the protection and sustainable use of native plant species and domestic breeds of farm animals.** There is inadequate implementation of EU law on nature protection, rare habitats, and species.[156]

- Slovakia achieves below-average results in RDI, as well as in patents and scientific citations related to the environment. The new investment support structure governed by the Partnership Council in regions is not sufficiently developed and requires additional administrative support. Some progress has been made in

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[150] OECD: *Environmental Performance Reviews Slovakia 2024 report*. Available at: https://www.oecd.org/slovakia/oecd-environmental-performance-reviews-slovak-republic-2024-108238e8-en.htm
[151] OECD: *Closing the loop in the Slovak Republic. A roadmap towards circularity for competitiveness, eco-innovation and sustainability.* Available at: https://www.oecd-ilibrary.org/docserver/acadd43a-en.pdf?expires=1721035647&id=id&accname=guest&checksum=BBEBCC2EB31253627C88665ACA764C29
[152] Lazíková, Jarmila; Banlerová, Anna; Lazíková, Zuzana: *Legislation on land protection in Slovakia*. Available at: https://real.mtak.hu/111247/1/170-Article%20Text-619-1-10-20200612.pdf
[153] European Commission*: 2022 Country Report – Slovakia.* Available at : https://commission.europa.eu/system/files/2022-05/2022-european-semester-country-report-slovakia_en.pdf
[154] OECD: *Environmental Performance Reviews Slovakia 2024 report*. Available at: https://www.oecd.org/slovakia/oecd-environmental-performance-reviews-slovak-republic-2024-108238e8-en.htm
[155] OECD: *Environmental Performance Reviews Slovakia 2024 report*. Available at: https://www.oecd.org/slovakia/oecd-environmental-performance-reviews-slovak-republic-2024-108238e8-en.htm
[156] Institute of Environmental Policy: *Greener Slovakia*. Available at: https://faolex.fao.org/docs/pdf/slo211277.pdf

strengthening local self-government, but overall territorial consolidation reform for municipalities is still ongoing. **In practice, landscape planning is not systematically applied.** Identified challenges include misunderstandings about the importance of landscape-ecological documentation in spatial planning processes, complexity of methodologies, lack of capacity for methodology implementation, poor quality control, and reluctance to integrate landscape-ecological documentation into spatial planning and land consolidation projects.[157]

Thematic Support Area in the Priority Area 5-4

Food Competitiveness and Climate Resilience	
Priority Area 5-4: Biodiversity Management[158] and Climate Change Adaptation	5.4.1. Innovative Solutions for Biodiversity Management in Relation to the Impact of Climate Change

Target state of the Priority Area 5-4

- **Increased support for adaptation and mitigation measures to reduce the impacts of climate change on agricultural and forest land.**
- **Established rules for sustainable land use and preparedness for challenges related to global megatrends** through biodiversity management.
- **Implemented innovative solutions for biodiversity conservation and increased sustainability** in the management of available genetic resources.
- **Adopted measures to improve species diversity** of ecosystems.
- **Greater support for the protection and sustainable use of native** plant species and domestic breeds of farm animals.
- **Support for sustainable land use systems, including sustainable forestry practices in Slovakia.**
- **Implemented innovative solutions for environmental problems** directly impacting environmental quality and health, air quality, waste management, pollution, and their effects on public health.
- **Applied innovative approaches to identify and mitigate risks** related to plant diseases, invasive and non-native species, and genetic vulnerabilities of agricultural varieties and breeds.
- **Adopted and implemented measures to preserve native species of cultivated plants and breeds** of farm animals for genetic diversity and resilience of local ecosystems.

[157] OECD: *Environmental Performance Reviews Slovakia 2024 report*. Available at: https://www.oecd.org/slovakia/oecd-environmental-performance-reviews-slovak-republic-2024-108238e8-en.htm

[158] Biodiversity management refers to the governance of ecosystems and species diversity in agricultural and forest landscapes to ensure a balance between economic activities and nature conservation. The goal is to protect native species, maintain genetic diversity, and preserve ecosystem functions.

- **Increased level of greening through eco-design, eco-innovation**, the use of secondary raw materials in production, and material recycling.

- **Improved inefficient public investment management in Slovakia** to unlock the country's full investment potential.

Cross-cutting Themes for Support within the Food Competitiveness and Climate Resilience Domain

An additional output of the work of the Food Competitiveness and Climate Resilience domain is the definition of cross-cutting themes across all thematic support areas within the priority area. The definition of cross-cutting themes is part of Annex 7.2.

6. List of Tables

7. Appendices

7.1 Appendix 1: Mission Health

Mission Health is a strategic initiative inspired by the Horizon Europe research and innovation program Mission Cancer[159], focusing on addressing the greatest challenges in healthcare in Slovakia. It represents a new approach to public policymaking aimed at delivering concrete solutions to some of the most significant societal challenges faced by Slovakia. This approach enables better targeting and coordination of resources to tackle major challenges with enormous socio-economic impacts. At the same time, it offers an opportunity to accelerate the creation and implementation of breakthrough methods, processes, and technologies that will have a significant positive impact on healthcare in Slovakia.

Connection of the Mission Health concept with the EDP process

Mission Health (the pilot mission for Slovakia) was approved by the Healthy Society domain as one of the priority themes and investments within the allocation of European funds PSK 2021-2027 in the RDI area of Healthy Society. The Healthy Society domain sees Mission Health as an important step in the RIS3+ EDP process, aiming to link outputs from research, development, and innovation to the most pressing problems of citizens and patients in the health sector.

Goals and benefits of Mission Health

Mission Health has an ambitious plan to deliver tangible results by 2030 in improving healthcare in Slovakia. The goal is not only to enhance the quality of healthcare but also to create and implement innovative methods, processes, and technologies that will positively influence the health and quality of life of the population. This approach also serves as a strategic mechanism within the approved National Strategy for Research, Development and Innovation 2030, which emphasizes the need to address societal challenges through innovation.

Joint Effort and Ecosystem Engagement

Mission Health is being developed in close collaboration with the Slovak research, innovation, and healthcare ecosystem. A key aspect of the mission is its time limitation, measurability, and clarity for citizens. Through joint effort, it will be possible to mobilize local, national, and European resources, ensuring the effective implementation of the Health Mission.

Outlook to 2030

By 2030, the Mission Health aims to deliver concrete, measurable, and tangible results that improve healthcare in Slovakia in priority areas.

Main Goal of the Mission Health

The Healthy Society domain began the preparation process of the Health Mission in the summer of 2023, when, based on a comprehensive analysis, it defined the main goal of the Mission Health:

[159] European Commission. *EU Mission: Cancer*. Available at: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/eu-mission-cancer_en

By 2030, we will improve the quality of life for nearly 3 million citizens through prevention, screening, early detection, accurate diagnosis and treatment, and thanks to a functional model of managing the citizen/patient journey in the areas of cancer, brain diseases, cardiovascular system diseases, and the children's subcategory.
Mission Health defines a roadmap of projects and measures with the greatest impact on mitigating or eliminating problems and their causes, and through the implementation of innovative solutions, processes, technologies, and systemic changes, it will bring better outcomes that will be reflected in the medium and long term by a reduction in preventable deaths.

Priorities of Mission Health

The priorities were defined based on a comprehensive analysis that identified three therapeutic areas:

- oncology,
- neurology,
- cardiology, and
- children´s healthcare.

The expert teams of the Health Mission subsequently defined the priority diagnoses based on the highest incidence of diseases in the Slovak population.

Solutions Map – Projects, measures, and categorization of solutions

The solution map is based on the definition of goals and measurable indicators for the diagnoses included in Mission Health. It builds on the list of problems and their causes for which we need to find solutions. The solution map identifies specific measures and projects necessary to improve the quality of care in the given areas.

Each solution will be described in detail, including objectives, expected outcomes, responsible institutions, and methods of implementation. For each solution, the allocation of financial resources and identification of the source (state budget, EU funds, multi-source) will be estimated.

In addition to the main proposed solutions, the map will include supplementary proposals from other relevant partners such as patient organizations, professional societies, representatives of the outpatient sector, medical faculties, nurses, healthcare workers, palliative and long-term care providers, health insurance companies, and others.

Areas of Support

Support will be directed toward priority areas of healthcare, specifically oncology, neurology, cardiovascular diseases, and pediatric care. Projects and solutions that mitigate or eliminate defined problems and their causes, and that bring potential improvements in the quality of healthcare for citizens—including impacts on quality-of-life indicators such as avoidable mortality and disability-adjusted life years (DALYs) will be supported.

Main Outputs

The implementation of the defined map of projects and measures, which are interconnected, should bring tangible results felt by citizens and patients in Slovak healthcare by 2030. The mission will support long-term

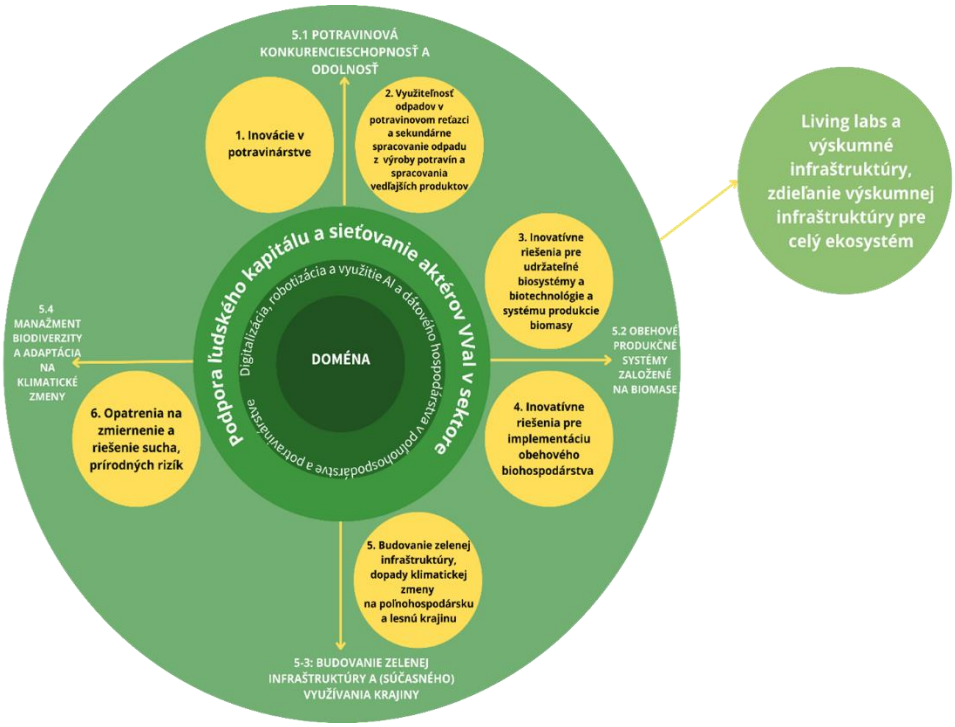
reform efforts, pilot projects, scaling of successful pilots, and establishment of systemic mechanisms for more effective management of the patient journey, systemic mechanisms for introducing innovations into healthcare (“Innovation Reimbursement Mechanism”), and a data hub—mechanism for secondary data use to support state health policy, research, development and innovation, analytical purposes, and fulfilling obligations arising from the EHDS Regulation (European Health Data Space).

Strategic Documents

Mission Health aligns with several national and European strategic documents, including the feasibility study for the Mission Health (finalized in April 2024), the Healthy Society Domain – SK RIS3 2021+, the National Strategy for Research, Development and Innovation 2030, the National Oncology Program, the updated Strategic Health Care Framework for 2014–2030, and EU Missions – Horizon Europe.

7.2 Appendix 2: Cross-cutting Themes for Supporting the Areas of the Domain Food Competitiveness and Climate Resilience

The expert working group of the Food Competitiveness and Climate Resilience domain identified priorities for individual priority areas of the domain based on the existing status of Transformation Maps. Throughout the process, they relied on two main criteria: economic added value and innovative potential. The survey involved 34 experts out of 42. According to the experts, innovations aimed at increasing the competitiveness of food producers represent the greatest economic added value. The results determined the main priorities for each priority area. After the update, the domain remains divided into four priority areas, each including priority topics selected by experts during prioritization. Out of 56 priorities in the status, 6 were selected along with 3 cross-cutting priorities. Based on the resulting priorities and expert agreement, the names of the priority areas and the domain itself were also changed.



The graph is divided into four main parts. Each part represents a Priority Area of the Domain, and the individual priority areas are graphically depicted in yellow circles as the main priorities. The center of the graph represents the Domain itself, and around the Domain are cross-cutting themes selected by experts that apply across all priority areas (support of human capital, digitization, robotics, and AI). The living lab, shown as a separate part of the diagram on the right side, represents an important tool for building innovation potential within the agri-sector. Living labs, as a key tool in the domain, are also identified as the area (solution) with the greatest innovation potential in the domain.

The main themes and priorities after the update are as follows:

<u>Priority Area 1: Food Competitiveness and Resilience</u>

1. Innovations in food processing
2. Utilization of waste in the food chain and secondary processing of food production waste and by-products

Priority Area 2: Circular Production Systems Based on Biomass

3. Innovative solutions for sustainable biosystems, biotechnology, and biomass production systems
4. Innovative solutions for implementing circular bioeconomy

Priority Area 3: Building Green Infrastructure and (Current) Land Use

5. Building green infrastructure, impacts of climate change on agricultural and forest land

Priority Area 4: Biodiversity Management and Climate Change Adaptation

6. Measures to mitigate and address drought and natural risks

Cross-cutting themes and priorities after the update are:

1. Living labs and research infrastructures, sharing research infrastructure across the entire ecosystem
2. Support of human capital and networking of RDI actors in the sector
3. Digitization, robotics, and the use of AI and data economy in food processing and agriculture