

RESEARCH INFRASTRUCTURES IN THE GLOBAL SPOTLIGHT- CHALLENGES AND OPPORTUNITIES FOR AGRICULTURE, BIOECONOMY AND RURAL DEVELOPMENT

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Abstract

Research infrastructures are considered the pathway towards a prosperous economy and societal well-being in a long-term perspective. Based on these grounds, the European Commission emphasizes the role and importance of setting-up research infrastructures, at both European and International level, by promoting scientific excellence and frontier research. In this context, the purpose of this article is to present the framework and features of such research infrastructures. The document conveys the full involvement and commitment from the European Commission, in both financially and strategic terms, to build specific research infrastructures with the aim of addressing the big challenges that modern society faces in a fast-changing environment. Nevertheless, in spite of all efforts made, the financial sustainability still remains the main issue to which the decision-makers have to come up with solutions and ways of making these infrastructures everlasting in order to fulfil their mission, to achieve great objectives and priceless results for the benefit of the whole society.

Key words: Research Infrastructure, ESFRI, Roadmap, research & innovation, agriculture

INTRODUCTION

The European Commission (EC) stresses that ‘research and innovation’ is the primary driver of the European economic growth and global prosperity, as well.

Knowledge and technology development contribute to the overall progress of the world economy and society. This is the reason for which the EC puts an emphasis on creating large and complex research infrastructures (RIs) that attract world-class researchers [14] and cutting-edge technologies so as to boost innovative discoveries in strategic areas (energy, environment, health & food, physical sciences & engineering, social & cultural innovation, digitalization). To this end, the EC set up European Strategy Forum on Research Infrastructures (ESFRI) a forum designed to prepare the policies on European Union (EU) research infrastructures [13] and to facilitate multilateral agreements and to offer guidance

and financial support to those pursuing the creation of such infrastructures [5].

To tackle the global challenges such as scarce resources, demographic change, human health, food security and so on, it is necessary to embrace a more collaborative, interdisciplinary approach, pooling equipment, researchers and money [1] to co-create added-value. Only in this way, research organizations can co-create new knowledge, technology, products and services that will bring long-term multiple benefits for the whole society.

Agriculture, bioeconomy and biotechnology play a major role in several RIs which address great challenges in energy, environment and health & food areas.

The whole environment and its negative changes have a strong impact on population health, food production and food security, demographic change, sustainable agriculture and forestry, bioeconomy and so on.

World food demand is expected to grow exponentially reaching 100% by 2050, opposite to crop yield (e.g., wheat, maize and soybean) and livestock production which face a significant decrease due to extreme climate changes. Consequently, substantial improvements and action measures should be taken urgently to secure food production by increasing both crop yield and livestock production. To this end, one option is to foster the usage of precision agriculture which is considered to be the future of farming in Europe [4]. By doing so, we not only increase food supply, but we also ensure the rural development in the long run.

All in all, Health & Food RIs along with Environmental RIs and Energy RIs are critical to tackle the challenges associated with agriculture, bioenergy, food and non-food systems.

MATERIALS AND METHODS

For analysing the context and necessity of setting-up ESFRI research infrastructures, a range of data and information was collected and processed from reliable sources, such as relevant, official webpages, press releases, documents and reports published mainly by EC and ESFRI.

Various tables, charts and diagrams were created for a visual representation of the results of the RIs analysis.

The financial data related to the structure, typology, level of maturity and costs of RIs are based on the provisions of ESFRI Roadmaps [4] and the Romanian Roadmap of Research Infrastructures [16].

The European Map indicating the countries which elaborated national roadmaps was prepared according to the official data posted by ESFRI on <https://www.esfri.eu/national-roadmaps> [2].

RESULTS AND DISCUSSIONS

Brief history of the EC policy on research

Since the '50s, 'research and innovation' has been put in the spotlight of the European community and opened the path towards research programmes.

In 1984, the first Framework Programme for research was launched and in 1986, 'research' has officially become a community policy aiming to strengthen the scientific and technological basis of the European industry and to encourage development of its competitiveness at international level.

Later on, in 2000, the EU created the European Research Area to support the free circulation of research technology and scientific knowledge. Subsequently, the EU showed ongoing support and full commitment for R&I allocating significant funds, higher from one programme to the following one in the pursuit of achieving its strategic objectives and raising awareness among national governments and private sector that this is the only way to a better society, translated into an efficient resources utilization, environmental protection, poverty and social exclusion combat, etc. [8]. As such, for the new programming period 2021-2027, the EC allocated a budget of 100 billion euros for Horizon Europe (HE) which will be distributed through three main pillars (Fig.1), as follows:

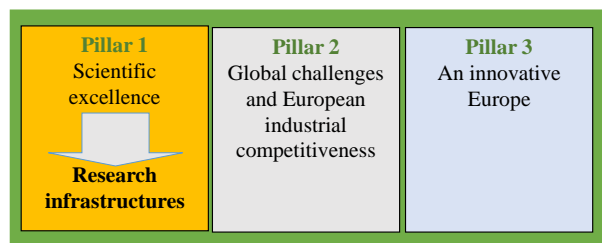


Fig. 1. The three pillars of HE

Source: European Commission, Horizon Europe - The next EU research & innovation investment programme (2021 – 2027) [9].

2.4 billion euros are dedicated to sustain integrated and interconnected RIs [9], as they incur substantial funds due to their mission and complexity.

Scope of RIs

According to the EC, two thirds of EU economic growth come from research and innovation, accounting for 15% of labor productivity growth in Europe over the period 2000-2013 [7].

Therefore, RIs play an essential role in promoting a higher cohesion in Europe by facilitating the excellence science [11]. Their

scope is to find the best solutions to the global societal, environmental and economic challenges (e.g., sustainable development) that modern society faces. Their contribution is of utmost importance to the world prosperity, by offering new technologies, sustainable solutions and disruptive innovations.

A proper distribution of RIs will contribute to reducing the “excellence gap” caused by the different capacities of research organisations in various countries [6]. Investments in RIs will lead to increasing regional competitiveness and hence, will trigger the regional development on the long term.

Moreover, RIs offer to researchers the facilities and instruments needed to perform the research activities at the highest level in order to achieve the highest goals, to generate new knowledge and technology.

Typology of RIs

The EC defines research infrastructures as “facilities, resources and services” which are used by the scientific community to perform cutting-edge research activities and enhance innovation in their areas of intervention. RIs entail major research equipment or instruments, important databases used by high qualified researchers for attaining scientific excellence in research and innovation. Such infrastructures are classified into 'single-sited', 'virtual' or 'distributed' [12].

Single-site RIs represent research facilities that are geographically located in a single location or in several complementary sites having European or international governance (e.g., FAIR, EST, ILL). This allows the research community to use resources and services which are located in a single site/complementary sites, even if its governance may include several countries [3].

Distributed RIs (Fig.2) represent research facilities that are geographically dispersed. They consist of a Central Hub and an interconnected network of National Nodes, the facilities being located in different locations (e.g., ACTRIS, DANUBIUS-RI, ELI) [10].

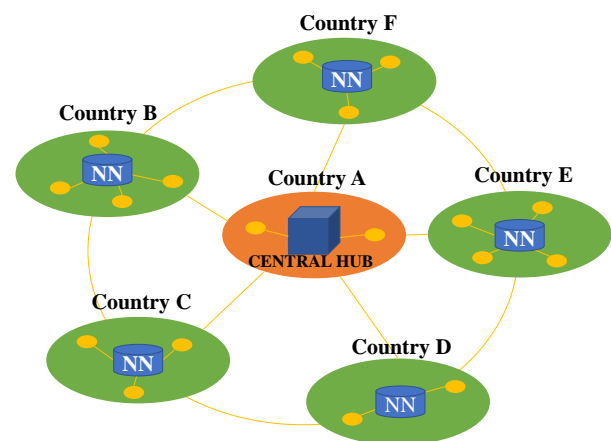


Fig. 2. Distributed RIs
 Source: European Commission - Supporting the Transformative Impact of Research Infrastructures on European Research [10].

Virtual/ electronic RIs represent research facilities consisting in electronic infrastructure, providing electronic services, networks, archives and databases (e.g. PRACE) [6].

As it can be seen in Fig.3, in addition to the definition given by the EC, MERIL platform includes a fourth type of RIs, namely **mobile RIs**, referring to vehicles specifically designed for scientific research, all virtual RIs being considered mobile as well [15].

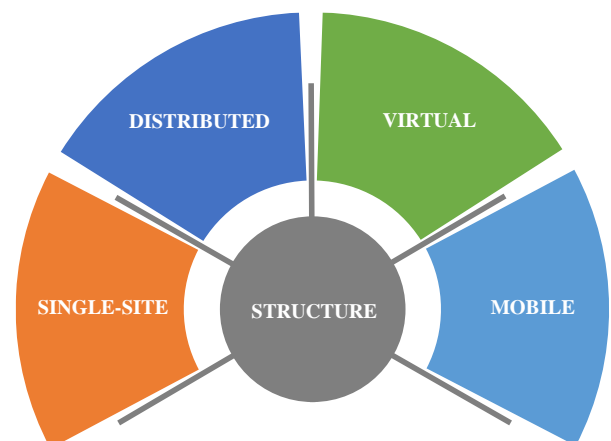


Fig. 3. RIs depending on structure
 Source: Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 establishing Horizon 2020 - The Framework Programme for Research and Innovation (2014-2020) and Repealing Decision No 1982/2006/Ec, Article 2, paragraph (6). Official Journal of the European Union. www.portal.meril.eu/meril/[15].

Depending on the maturity level, ESFRI RIs can be classified into three types as shown in Fig. 4.

ESFRI Emerging Projects are those in the inception phase when the research organizations are forming the consortium, identifying main RI's objectives, performing a rough estimate of costs, so, at this stage the RIs are at a low level of maturity [16].

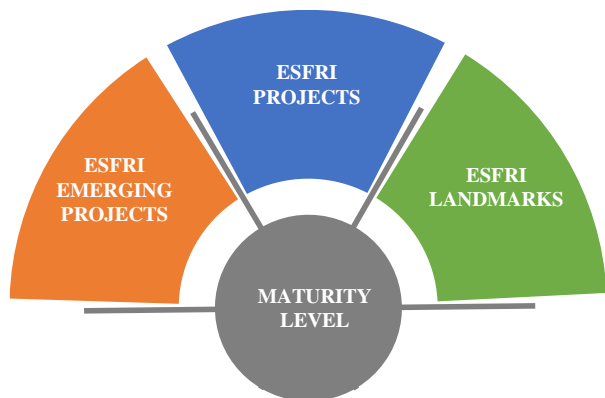


Fig. 4. RIs depending on the maturity level
 Source: ESFRI Public Roadmap 2018 Guide
 Romanian Committee for Research Infrastructures (Comitetul Român pentru Infrastructuri de Cercetare - CRIC), 2017, Romanian Roadmap of Research Infrastructures [16].

ESFRI Projects are those considered by ESFRI as being active and included in the preparation phase. These RIs have reached a high level of maturity and have a well-defined structure and governance; At the end of the preparation phase, the RI will be registered as a new legal entity/ association [3].

ESFRI Landmarks are RIs included in the implementation or construction phase which means that RIs needs to make the adequate investments in order to become fully operational [3].

Also, depending on the location (Fig. 5), RIs can be grouped by:

National RIs refer to RIs located in one country having an impact at national level

Regional RIs refer to RIs serving a specific objective which contributes to the development of a specific region of the country.

Macro-regional RIs refer to RIs located in a European region aiming to address some regional challenges

European/International RIs refer to RIs developed for instance under ESFRI

Roadmap, having multiple locations in different countries.

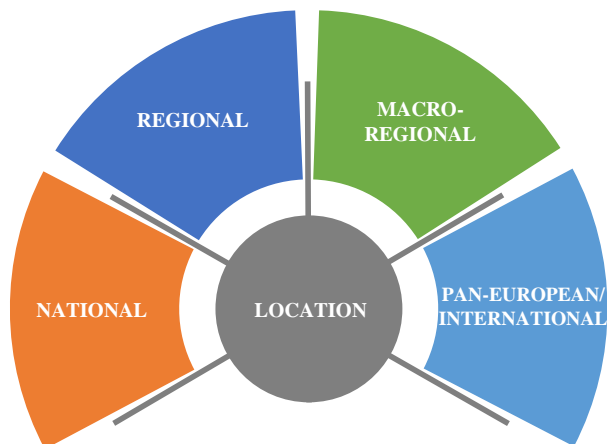


Fig. 5. RIs depending on geographical area
 Source: Romanian Committee for Research Infrastructures (Comitetul Român pentru Infrastructuri de Cercetare - CRIC), 2017, Romanian Roadmap of Research Infrastructures [16].

Roadmap

ESFRI Roadmap is a key tool through which ESFRI sets out a long-term European strategic planning for the development of RIs. However, the inclusion in the ESFRI Roadmap does not guarantee the construction of a RI.

ESFRI Roadmap identifies new pan-European research infrastructures or major upgrades to existing ones, meeting the needs of European research communities over the 10–20-year horizon. Also, it presents a list of different research infrastructures according to size, phase, scope and complexity. It is regularly updated based on the needs of the European scientific community for research infrastructures.

The EC and ESFRI foster Member States and associated countries to adopt national Roadmaps for Research Infrastructures. The national Roadmap forms the basis of a strategic planning that facilitate governments to set national priorities and allocate funds to national and European RIs, including ESFRIs. Therefore, it serves as a strategic planning tool and reference document for decision-making in the field of research and innovation [16]. It is used in monitoring and evaluating the progress made by research infrastructures in Romania with national, European and international relevance.

Fig. 6 shows the current countries that implemented a national roadmap while others are in the process of preparing their roadmaps [2].



Fig. 6. Countries having implemented national roadmaps
 Source: ESFRI National Roadmaps, www.esfri.eu/national-roadmaps, Accessed on 21.03.2021 [2].

Lifecycle

Each RI sustained by ESFRI has to pass throughout different phases (Fig.7) starting from the project identification, then designing and preparation and eventually, if ESFRI considers that the project is sufficient mature in terms of legal, organisational, financial aspects and so on, the RI will be implemented and get ready to full operation.

Each phase involves performing several tasks, as follows [3]:

Phase 1 - Concept Development: defining the concept, establishing the project consortium, identifying financing sources, setting project and scientific management

Phase 2 – Design: preparing design study and business case, finding political and economic support from ministries, defining the access policy, preparing a top-level breakdown of costs, defining governance and HR

Phase 3 – Preparation: elaborating the business plan and the cost book, securing political and financial support, describing data

policy and data management plan, defining the legal form of RI

Phase 4 – Implementation: construction and deployment of RI, recruitment of personnel, IPR & innovation policies, operational and upgrade plan, securing funding for RI operation

Phase 5 – Operation: achieving frontier research results, performing services to scientific community, outreach activities, upgrading the facilities, securing ongoing political and financial support

Phase 6 – Termination: dissolution, dismantling of facilities, reuse, merger of operations and organisation

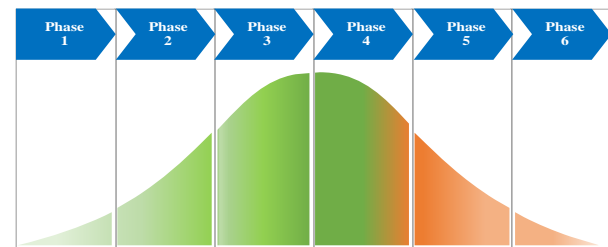


Fig. 7. Lifecycle of RIs

Source: ESFRI Public Roadmap 2018 Guide [3].

Current situation of ESFRI RIs [5]

The first edition of ESFRI Roadmap was published in 2006 and included 35 projects. The list has been monitored and continuously updated in the subsequent editions in 2008, 2010, 2016 and 2018, the latter being the latest, displaying a number of 55 of pan-European RIs, out of which 18 ESFRI Projects and 37 ESFRI Landmarks.

The RIs are listed by the 6 key areas of intervention which have been defined by the EC as primary goal for action: energy (EN), environment (ENV), health & food (H&F), physical sciences & engineering (PHSC & ENG), social & cultural innovation (S&C INNOV) and digitalisation (DIG).

As it can be noted in Fig.8, most of ESFRI projects are distributed RIs, 15 in total, while only 3 are single-sited RIs.

This means that the research organisations are focusing on achieving objectives with wider impact at European or international level.

It is worth mentioning that this indicates that research organizations are willing to share assets, knowledge and expertise, as well as to strongly collaborate to fulfill great objectives.

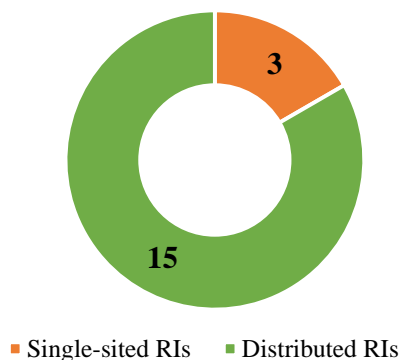


Fig. 8. ESFRI Projects
 Source: Own calculations based on ESFRI Strategy Report on Research Infrastructures Roadmap 2021 Public Guide [4].

Health & Food area is the main concern of the ESFRI Projects (6 projects), followed by environment (4 projects), both of them weighting more than 50% in total of ESFRI Projects (Fig. 9).

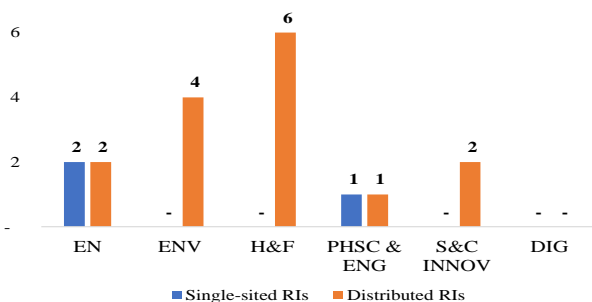


Fig. 9. ESFRI Projects in key areas
 Source: ESFRI Strategy Report on Research Infrastructures Roadmap 2021 Public Guide [4].

There is no good or bad approach, nor an obligation related to the structure of an RI, the decision depending on the objectives and activities proposed, partners involved, impact of research results and of course, the recommendations made by ESFRI in the early phase. However, the maturity level is decided by ESFRI based on the proposal submitted by the RI, followed by a hearing with ESFRI representatives.

Some examples of RIs connected to agriculture and biotechnology are presented below:

AnaEE (Infrastructure for Analysis and Experimentation on Ecosystems) - State-of-the-art experimental facilities, to support scientists in testing the potential impacts of climate change and land use in Europe, and forecasting

the risks on European ecosystems, including agricultural systems [4].

EU-IBISBA (European Industrial Biotechnology Innovation and Synthetic Biology Accelerator) - Industrial biotechnology with applications in energy (liquid biofuels), chemicals (organic acids), materials (bioplastics) and ingredients for the food, feed, cosmetics and pharma sectors (enzymes, antioxidants, antibiotics) [4].

METROFOOD-RI (Infrastructure for promoting Metrology in Food and Nutrition) - High quality metrology services in food and nutrition, comprising an important cross-section of highly inter-disciplinary and interconnected fields throughout the food value chain, including agro-food, sustainable development, food safety, quality, traceability and authenticity, environmental safety, and human health [4].

MIRRI (Microbial Resource Research Infrastructure) - Offering long-term deposition of raw material of high scientific and economic value for basic research and innovation in biotechnology [4].

Regarding the ESFRI Landmarks (Fig.10), distributed RIs are twice as number (25) compared to single-sited RIs (12).

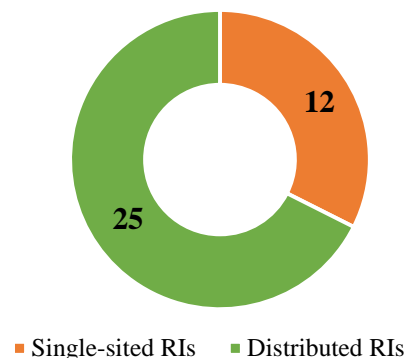


Fig. 10. ESFRI Landmarks
 Source: Own calculations based on ESFRI Strategy Report on Research Infrastructures Roadmap 2021 Public Guide [4].

However, in terms of the topic selected (Fig.11), ‘Physical sciences & engineering’ area (12 projects) is on the top being mostly established as single-sited, very closely followed by ‘health & food’ area with 10 projects.

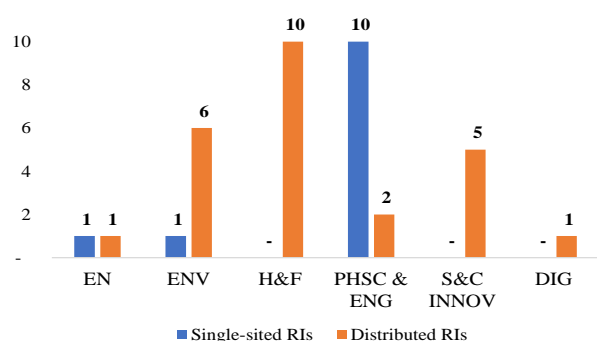


Fig. 11. ESFRI Landmarks in key areas
 Source: Own calculations based on ESFRI Strategy Report on Research Infrastructures Roadmap 2021 Public Guide [4].

Some examples of RIs connected to agriculture and biotechnology are presented below:

ICOS ERIC (Integrated Carbon Observation System) - High precision measurement on carbon cycle in agricultural systems, support for climate-smart agriculture, evaluation of bioenergy, common analyses of plant and microbial adaptation to change in relation to carbon cycle [4].

LifeWatch ERIC (e-Infrastructure for Biodiversity and Ecosystem Research) - Advancement of scientific and technological research on conservation of biodiversity in species of agricultural interests, ecosystem impacts on/from agriculture, fisheries and aquaculture [4].

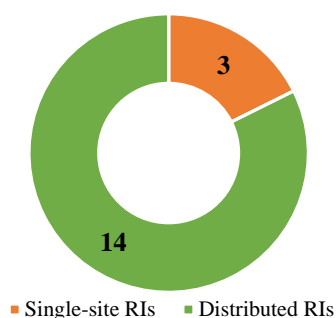


Fig. 12. Situation of RIs sustained by ESFRI in which Romania is member depending on the RI's structure
 Source: Own calculations based on ESFRI Strategy Report on Research Infrastructures Roadmap 2021 Public Guide [4].

EU-OPENSREEN ERIC (European Infrastructure of Open Screening Platforms for Chemical Biology) - Developing novel small chemical compounds which elicit specific biological responses on organisms,

cells or cellular components. It also covers the production of crop-protective compounds, which are of paramount importance to society via the understanding of the response of wild or crop plants to environmental and agricultural substances [4].

Romania is included as member in 17 ESFRI RIs (Fig.12) thereof, 14 are distributed and 3 single-sited, weighting around 31% in total ESFRI RIs.

As regards the level of maturity (Fig.13), Romania is mainly part of ESFRI Landmarks (12 projects) which represent projects under the implementation phase and therefore, considered by ESFRI as sufficient mature to be established and able to start their operation. The Romanian research organisations committed to bring their contributions in the following areas (Fig.14): environment (6 projects), physical sciences & engineering (5 projects), health & food (3 projects) and social & culture innovation (3 projects).

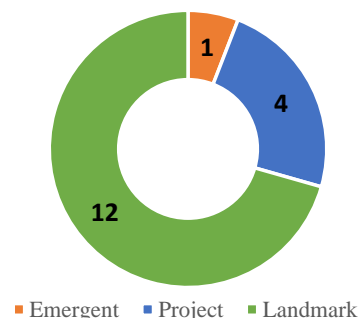


Fig. 13. Situation of RIs sustained by ESFRI in which Romania is member depending on the maturity level
 Source: Own calculations based on ESFRI Strategy Report on Research Infrastructures Roadmap 2021 Public Guide [4].

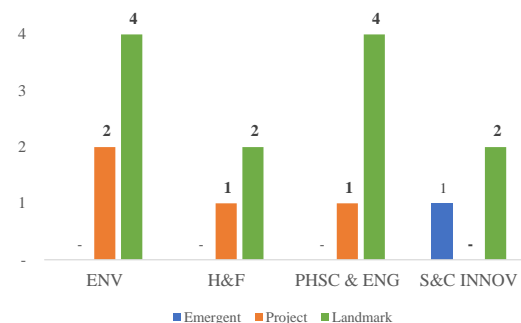


Fig. 14. Situation of RIs sustained by ESFRI in which Romania is member
 Source: Own calculations based on ESFRI Strategy Report on Research Infrastructures Roadmap 2021 Public Guide [4].

Costs incurred in setting-up ESFRI RIs

ESFRI requires applicants to prepare a cost book analysis and a business plan with the aim of calculating the costs for project implementation and operation. Based on the estimated costs, the applicants have to show the potential financing sources starting with the provision of economic endorsements from the national governments involved in the project, expressing their financial commitment to the creation of the RI.

The analysis of these RIs, shows that the operation costs weight nearly 10% of the implementation costs for the majority of RIs.

As of ESFRI Roadmap 2018, ESFRI Projects, estimated the highest costs for the implementation of projects in the environment area (Fig.15) with around 4.1 billion euros, followed by energy with 1.7 billion euros.

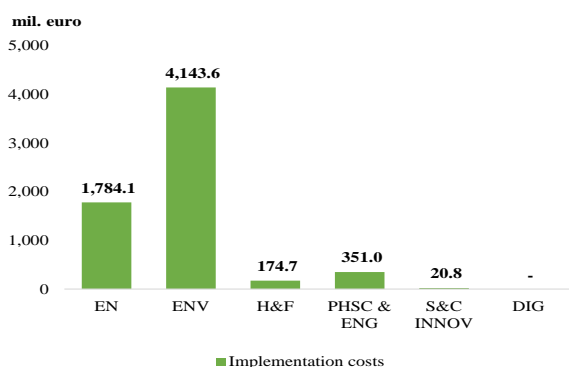


Fig. 15. Implementation costs of ESFRI Projects
 Source: Own calculations based on ESFRI Strategy Report on Research Infrastructures Roadmap 2021 Public Guide [4].

On the other side, ‘health and food’ area seems to require almost 40% for operation costs (Fig.16).

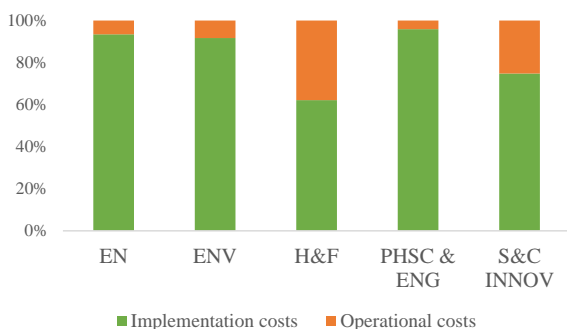


Fig. 16. Cost structure of ESFRI Projects
 Source: Own calculations based on ESFRI Strategy Report on Research Infrastructures Roadmap 2021 Public Guide [4].

In respect of the implementation costs estimated by ESFRI Landmarks, ‘physical sciences & engineering’ area requires approximately 8.9 billion euros, followed at long distance by ‘energy’ area with 2.8 billion euros. On the other side, operational costs (Fig. 18) fall within the average value estimated. Considering the phase, we can state that costs of ESFRI Landmarks (projects in the implementation phase) are more accurate than costs of ESFRI Projects (projects in the preparation phase).

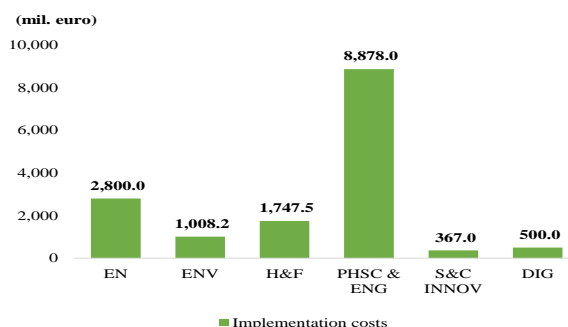


Fig. 17. Implementation costs of ESFRI Landmarks
 Source: Own calculations based on ESFRI Strategy Report on Research Infrastructures Roadmap 2021 Public Guide [4].

Regarding the implementation or operational costs, it is important to highlight that there is no rule, no lower or upper limit set for the creation of an RI, but this should be estimated considering the government support, the potential financing sources, other grants or revenues generated by RI from paid services (if any) and somehow balanced with the investment needs in performing high-quality research activities so that to fulfil the pre-set objectives and to obtain remarkable results.

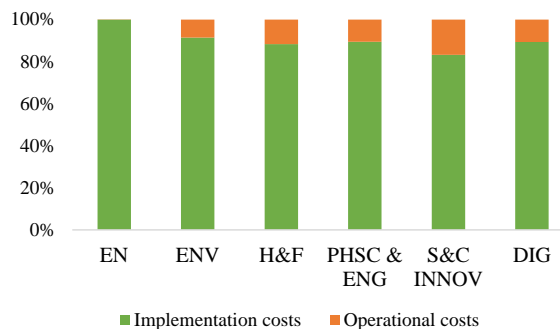


Fig. 18. Cost structure of ESFRI Landmarks
 Source: Own calculations based on ESFRI Strategy Report on Research Infrastructures Roadmap 2021 Public Guide [4].

Overall, it is worth mentioning, that the difference between the values laid down in Fig. 15 and the ones in Fig. 17 comes from a range of variables such as number of projects per area, project phase, area of intervention, number of partners, project type and complexity.

CONCLUSIONS

It is worldwide acknowledged that scientific excellence is the main trigger for rapid progress of research, regardless of scientific area.

By sharing knowledge and technology, synergies will occur, avoiding thus the duplication of efforts. In this way, large RIs ensure that science is led by excellence and not by the research capacity of each country. ESFRI sustains RIs all along their lifecycle to make sure they reach the right level of maturity in order to be implemented and also, invites the policy-makers of each country involved in the RIs to join their efforts by offering full political and economic support which will eventually, lead to the RIs materialization. Additionally, it encourages RIs partners to access both public and private funds available which can help them in making the necessary investments in research facilities/instruments and cover all costs incurred in carrying out their activities. Even so, due to the large amounts involved by these infrastructures, their sustainability on the long-term still remains a major issue/challenge that ESFRI tries to settle it.

A special attention should be paid to the rural development because this is the key to overcoming world hunger and poverty.

Research and innovation in agriculture and biotechnology is essential to finding proper solutions to the global challenges related to food security, well-being, environment and energy. Therefore, the EU draws attention on the need of creating pan-European RIs on food and nutrition, in sustainable agriculture and bio-economy.

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REFERENCES

- [1]ESFRI Brochure, 2013, European Research Infrastructures with global impact, https://www.dariah.eu/wp-content/uploads/2017/02/ESFRI_Brochure_210912_lores.pdf, Accessed on 21.03.2021.
- [2]ESFRI National Roadmaps, <https://www.esfri.eu/national-roadmaps>, Accessed on 21.03.2021.
- [3]ESFRI 2016, ESFRI Public Roadmap 2018 Guide.
- [4]ESFRI, 2021, ESFRI Strategy Report on Research Infrastructures Roadmap 2021 Public Guide, https://www.esfri.eu/sites/default/files/ESFRI_Roadmap2021_Public_Guide_Public.pdf, Accessed on 21.03.2021.
- [5]ESFRI White Paper, 2020, <https://www.esfri.eu/esfri-white-paper>, Accessed on 21.03.2021.
- [6]ESFRI, European Research Infrastructures for a smarter future Conference, <https://www.esfri.eu/esfri-events/european-research-infrastructures-smarter-future-conference?qt-event=1>, Accessed on 21.03.2021.
- [7]European Commission, Directorate-General for Research & Innovation, 2017, The economic rationale for public R&I funding and its impact, <https://op.europa.eu/en/publication-detail/-/publication/0635b07f-07bb-11e7-8a35-01aa75ed71a1>, Accessed on 21.03.2021.
- [8]European Commission Office for the EU Publications 2016, Research and Innovation, To understand the EU policies, (European Commission, Oficiul pentru Publicații al Uniunii Europene, 2016, Cercetare și inovare – Să înțelegem politicile Uniunii Europene), http://publications.europa.eu/resource/cellar/ba202c94-aa5d-11e6-aab7-01aa75ed71a1.0007.04/DOC_1, Accessed on 21.03.2021.
- [9]European Commission, Horizon Europe, The next research and innovation investment programme 2021-2027, https://ec.europa.eu/info/sites/default/files/research_and_innovation/strategy_on_research_and_innovation/presentations/horizon_europe_en_investing_to_shape_our_future.pdf, Accessed on 21.03.2021.
- [10]European Commission, 2020, Supporting the Transformative Impact of Research Infrastructures on European Research, https://ec.europa.eu/info/publications/supporting-transformative-impact-research-infrastructures-european-research_en, Accessed on 21.03.2021.

[11]European Commission, 2017, Sustainable European Research Infrastructures – A call for action.

[12]European Parliament, 2013, Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 establishing Horizon 2020 - The Framework Programme for Research and Innovation (2014-2020) and Repealing Decision No 1982/2006/Ec, Article 2, paragraph (6). Official Journal of the European Union.

[13]European Strategy Forum on Research Infrastructures, https://ec.europa.eu/info/research-and-innovation/strategy/european-research-infrastructures/esfri_en, Accessed on 21.03.2021.

[14]Geoghegan-Quinn, M., 2012, The importance of research infrastructures for Europe, Conference on research infrastructures, https://ec.europa.eu/commission/presscorner/detail/en/S_PEECH_12_207, Accessed on 21.03.2021.

[15]MERIL, Mapping the European Research Infrastructure Landscape, <https://portal.meril.eu/meril/>, Accessed on 21.03.2021.

[16]Romanian Committee for Research Infrastructures (Comitetul Român pentru Infrastructuri de Cercetare - CRIC), 2017, Romanian Roadmap of Research Infrastructures, <https://www.research.gov.ro/ro/articol/4201/despre-ancsi-comunicare-comitetul-roman-pentru-infrastructuri-de-cercetare-a-realizat-raportul-de-strategie-privind-infrastructurile-de-cercetare-din-romania>, Accessed on 21.03.2021.