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Prospects for Research, Development, Innovation and Technology Transfer in Romanian Horticulture

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Abstract: An analysis of the research, innovation and technology transfer environment carried out by the European Commission ranks Romania in one of the last places in Europe, mentioning the lack of investments in research, especially at the level of modern infrastructure and equipment, among the most important reasons. On the other hand, Romanian universities must face the competition at the international and the European level, in order to face the technical and socio-economic challenges both at the societal level, and with respect to the inherent technological evolutions. Under these conditions, this article presents a case study of a top university in Romania that has, for the first time in its history as an EU member, successfully implemented European structural funding investment and research grant for building a new advanced research institute at the level of excellence compatible with the most demanding expectations in the field of horticulture, and is using it in accordance with the standards of the European Research Area. In an analysis of the results of all horticultural labs covered by the new institute, also from a perspective of cross-cutting collaboration between them, during a 5-year study of sustainability, the model presented demonstrates the effectiveness and efficiency of European structural funds in the field of scientific research. It is a real success of advanced research, innovation, development, and technology transfer, which can be adopted by any other university in the EU.

Keywords: growth; innovation; economic development; technology transfer; entrepreneurship; horticulture

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1. Introduction

1.1. Innovation and Technology Transfer Worldwide

Innovation is defined in the literature as an idea, a concept, a process for designing, operationalizing, and experimenting with a new product model, new processes, or new functional structures for industrial application [1]. Innovation is the ability to take new ideas and translate them into commercial outcomes by new processes, products, or services [2,3]. "Innovation is the multi-stage process whereby organizations transform ideas into new/improved products, services or processes, in order to advance, compete and differentiate themselves successfully in their marketplace" [4].

Therefore, innovation, compared to invention, does not necessarily concern an absolute novelty, but makes the scope and speed of implementation more accessible [5,6]. From a very general point of view, innovation can be understood as a process from the generation of an idea to its commercialization—bringing the idea or invention to the market as a new product, process or service through the phases of idea generation, research and development, product development, marketing, and selling a new product or service. The idea becomes an invention, when it is converted into a tangible new artifact. Inventions are

necessary seeds for innovations, but the inventions do not inevitably lead to the innovation. Innovation is mostly regarded as the commercial and practical application of ideas or inventions [7], while other authors [8] consider that "technological innovation and high-quality economic development are inevitable requirements of sustainable development, and the digital economy has gradually become a new engine to enhance technological innovation and the high-quality development".

Technological transfer (TT) is seen either as a sub-process of innovation or as a step to complement the concept of innovation. Organizations dealing with TT are an interface between interested social groups: bidders of research results and potential applicants as well as beneficiaries. As the Bayh–Dole Act puts it, "the mission of university technology transfer offices (TTOs) is to transfer research results to commercial application for public use and benefit" [9], meaning the process of developing practical applications for the results of scientific research. This usually involves the identification of research, typically by dedicated TTOs in universities, governmental organizations, and companies, which have potential commercial interest and the design of strategies for how to exploit it in mind. Such strategies can include the creation of licensing agreements or joint ventures, partnerships, or spin-out companies to develop a new technology and bring it to market [10,11].

TT can be a significant source of revenues for the university and provide industry with important new technologies, and is seen as playing an increasingly significant role in stimulating economic development [12,13]. Successful TT does not end when the technology is handed over to industry, but rather it requires utilization of the technology in new products, processes, or innovative organizational changes [14,15]. Additionally, firms are concerned with the time to market because the benefits from innovation may depend on how quickly a new product can be developed [12]. Therefore, specialized faculty knowledge and involvement is necessary for firms to be willing to license and develop technologies in early stages [16,17].

To formulate an alternative view of TT, it is useful to identify the various factors that contribute to the TT process. Heinzl et al. [14] recognize factors that can influence university TT performance: funding structures, research activities, the university's legal environment, and the institutional setting. This process typically includes sifting for gold (identifying new technology) and knowing what to do with it when you find it, i.e., strategies for protection through patents and copyrights, the development of commercialization strategies such as technology development, marketing, and licensing to existing private companies, or the creation of new start-up companies based on the technology [4].

From a Higher Education perspective, spin-offs are defined as companies set up to exploit IP (intellectual property) that has originated from within the higher education institute. From a business perspective, a spin-off occurs when a division of a company or an organization becomes an independent business. The newly formed company usually obtains the assets, IP, technology, and/or existing products from the parent organization. A start-up company is a newly formed company that has a limited operating history. These companies, generally newly created, are in a phase of development and research for markets. Start-up companies can have a high element of risk associated with their development, but this can be balanced by their high potential rate of growth and scalability [10]. Spin-off and start-up companies provide academic entrepreneurs with an alternative pathway for disseminating and commercializing research, often when they are unable to license their technology to large companies or an external entrepreneur [18,19]. Sometimes a spin-off or start-up is the only option for developing a technology, and without the creation of a new entity that technology might never become commercially viable [20,21]. Furthermore, spin-offs and start-ups appropriate the value of their innovation and can provide opportunities for additional funding mechanisms to further their research agenda [22,23].

Spin-off creation benefits from support structures such as incubators or science/research parks within or close to the university [14,24]. Not all universities have a research park, but for those that do, university spin-offs are more likely to originate in science/research parks that are closest to the university, as well as in technology-focused science/research parks

such as those centered on biotechnology [25]. The potential rewards from spin-offs and start-ups create incentives for universities to engage in entrepreneurial activities [26].

1.2. Innovation and Technology Transfer in Romania

The European Commission, through the European Innovation Scoreboard, provides a comparative analysis of innovation performance in European countries and regional neighbors. It also evaluates relative strengths and weaknesses of national innovation systems and helps countries identify areas they need to address.

Studying the scoreboard of European innovation 2021 [27] in detail, it can be seen in Table 1 below that the strongest dimensions of Romanian innovation are digitalization and the impact of sales. Broadband penetration has risen above the EU average, as have exports of high-tech goods and venture capital. Recent increases in performance are seen in international scientific co-publications, most cited publications, number of foreign PhD students, and innovative SMEs collaborating with others. Innovators, firm investments, and human resources are the weakest dimensions of innovation. The lowest scores of indicators in Romania are in terms of lifelong learning, SMEs with product or process innovations, SMEs with marketing or organizational innovations, and innovative SMEs in the interior. For all four indicators, performance is the lowest in 2018 in all countries, leading to a relative score of 0.

Table 1. Romania 2014–2021, performance relative to EU 2014.

Romania	Relative to EU 2021 in		Performance Relative to EU 2014 in	
	2021		2014	2021
Summary Innovation Index	**31.2**		**31.0**	**35.1**
Human resources	**13.2**		**39.6**	**14.0**
New doctorate graduates	22.1		77.0	19.6
Population with tertiary education	10.9		13.2	14.0
Lifelong learning	4.0		5.6	4.4
Attractive research systems	**35.0**		**22.3**	**39.4**
International scientific co-publications	36.1		30.0	47.4
Most cited publications	40.5		19.8	39.8
Foreign doctorate students	24.0		17.7	28.5
Digitalization	**61.8**		**57.4**	**85.5**
Broadband penetration	100.0		104.9	151.7
People with above-basic overall digital skills	4.5		0.0	5.6
Finance and support	**28.7**		**24.7**	**34.2**
R&D expenditure in the public sector	3.6		21.1	3.5
Venture capital expenditures	72.6		28.3	122.0
Firm investments	**7.2**		**17.1**	**8.7**
R&D expenditure in the business sector	16.3		11.0	18.1
Non-R&D innovation expenditures	0.0		40.4	0.0
Innovation expenditures per employee	6.3		4.7	8.4
Use of information technologies	**26.1**		**11.1**	**30.2**
Enterprises providing ICT training	6.7		0.0	6.7
Employed ICT specialists	42.9		23.8	57.1
Innovators	**3.8**		**9.7**	**5.2**

Table 1. *Cont.*

Romania	Relative to EU 2021 in		Performance Relative to EU 2014 in	
	2021		2014	2021
Product innovators (SMEs)	7.8		0.0	11.0
Business process innovators (SMEs)	0.0		18.2	0.0
Linkages	**16.0**		**15.1**	**21.5**
Innovative SMEs collaborating with others	13.4		0.0	19.7
Public–private co-publications	20.8		19.9	24.5
Job-to-job mobility of HRST	0.0		10.3	0.0
Intellectual assets	**32.8**		**22.0**	**28.4**
PCT patent applications	6.3		4.7	5.5
Trademark applications	56.9		47.0	59.8
Design applications	26.1		12.6	17.9
Employment impacts	**10.3**		**4.4**	**10.5**
Employment in knowledge-intensive activities	23.2		10.7	25.3
Employment in innovative enterprises	0.0		0.0	0.0
Sales impacts	**79.9**		**55.9**	**81.4**
Medium- and high-tech product exports	100.8		92.1	110.4
Knowledge-intensive services exports	61.3		46.7	64.9
Sales of innovative products	72.4		19.4	63.0
Environmental sustainability	**38.2**		**61.4**	**39.8**
Resource productivity	10.6		7.7	15.7
Air emissions by fine particulate matter	66.4		59.9	70.6
Environment-related technologies	19.5		95.3	14.7

Source: European Innovation Scoreboard 2021 [27]. **Legend**: The colors show normalized performance in 2021 relative to that of the EU in 2021. Dark green: above 125%; light green: between 100% and 125%; yellow: between 70% and 100%; orange: below 70%. Normalized performance uses the data after a possible imputation of missing data and transformation of the data.

Further, in Table 2 below, structural differences with the EU are presented, including, compared to the EIS 2020, new information on different types of (innovative) enterprises (innovation profiles) and environmental indicators: GDP (gross domestic product) per capita, the employment share in services, and top R&D (research and development) spending enterprises per 10 million population are well below the EU average, while the average annual GDP growth, enterprise births, and total entrepreneurial activity are well above the EU average. However, many of the economic indicators in Romania tend to be closely above or beneath the EU value.

Romania was placed on the last positions among EU Member States in the last ten years, considering the share of GDP in R&D expenditure (Table 3). With only 0.4–0.5%, our country recorded less than a quarter of the EU average as allocation in this area. In fact, research and development are very much suffering at the level of the Romanian private initiative, so not only the state allocations are the key, but the creation of an incentive environment for this type of business. Scientific research, technological development, and innovation in Romania, according to data provided by the National Institute of Statistics [28], are presented as follows:

Table 2. Structural differences between Romania and the European Union.

Performance and Structure of the Economy	RO	EU
GDP per capita (PPS)	20,400	30,800
Average annual GDP growth (%)	0.4	−2.5
Employment share manufacturing (NACE C) (%)	18.8	16.5
of which high and medium high-tech (%)	33.9	37.9
Employment share services (NACE G-N) (%)	32.4	41.2
of which knowledge-intensive services (%)	26.8	35.1
Turnover share SMEs (%)	42.0	36.5
Turnover share large enterprises (%)	42.7	45.7
Foreign-controlled enterprises—share of value added (%)	15.9	11.8
Business and Entrepreneurship		
Enterprise births (10+ employees) (%)	2.2	1.0
Total entrepreneurial activity (TEA) (%)	10.8	6.7
FDI net inflows (% GDP)	2.9	2.0
Top R&D spending enterprises per 10 million population	0.0	16.2
Buyer sophistication (1 to 7 best)	2.8	3.7
Innovation Profiles		
In-house product innovators with market novelties	2.4	10.7
In-house product innovators without market novelties	5.0	12.3
In-house business process innovators	3.5	11.0
Innovators that do not develop innovations themselves	3.4	11.6
Innovation: active non-innovators	0.2	3.3
Non-innovators with potential to innovate	29.4	19.9
Non-innovators without disposition to innovate	2.8	3.7
Governance and Policy Framework		
Ease of starting a business (0 to 100 best)	73.0	76.5
Basic-school entrepreneurial education and training (1 to 5 best)	2.4	2.0
Govt. procurement of advanced tech products (1 to 7 best)	2.5	3.5
Rule of law (−2.5 to 2.5 best)	0.4	1.1
Climate Change Indicators		
Circular material use rate	1.6	11.7
Greenhouse gas emissions intensity of energy consumption	86.3	86.6
Eco-innovation index	57.0	100.0
Demography		
Population size (millions)	19.4	446.7
Average annual population growth (%)	−0.5	0.1
Population density (inhabitants/km^2)	83.7	108.8

Source: European Innovation Scoreboard 2021 [27].

Table 3. Scientific research, technological development, and innovation in Romania.

Year	Total Expenditure with R&D Activities as % of GDP	The Share of GDP in R&D Expenditure in the Enterprise Sector (%)	The Share of GDP in R&D Expenditure in the Public Sector (%)	Turnover in Innovation as % of Total Turnover by Economic Sectors			Innovative Enterprises% of Total Enterprises
				Total	Industry	Services	
2009	0.46	0.19	0.27				
2010	0.45	0.17	0.28	14.3	21.4	6.5	30.8
2011	0.49	0.18	0.31				
2012	0.48	0.19	0.29	3.7	5.4	1.6	20.7
2013	0.39	0.12	0.27				
2014	0.38	0.16	0.22	6.5	8.4	4.7	12.8
2015	0.49	0.22	0.27				
2016	0.48	0.27	0.21	4.7	7.2	2.6	10.2
2017	0.50	0.29	0.21				
2018	0.51	0.30	0.21	8.8	9.9	7.5	14.6
2019	0.48	9.28	0.20				
2020	0.47	0.28	0.19	-	-	-	-

Source: National Institute of Statistics [28].

The Research and Innovation analysis in the European Semester 2019 Country Reports [29], updated in the end of 2022, states a few important conclusions and future mandatory challenges for Romania [30]:

- A sound, sustainable, and open strategy for public and private investments in R&I (research and innovation) infrastructure, education, healthcare, social inclusion, and innovation, to be open to all relevant users, and moving towards higher added value activities, would improve the performances in R&I, productivity, and competitiveness on the EU market and long-term growth;

- The economy's overall R&I capacity remains low and could be improved by increased science–business cooperation, and technology imports need to be substituted with home-grown innovation;
- Investment in R&D remains critically low, being the lowest in the EU (0.5% of GDP);
- Public R&D funding is insufficient and declined from 0.32% of GDP in 2011 to 0.21% of GDP in 2017, impeding any innovation potential;
- Digitalization is a key challenge for boosting innovation and competitiveness.

As a direct consequence to these low performances in the R&I area, the European Commission stressed a few specific investment recommendations for Romania [31]:

- To focus investment-related economic policies on transport, notably on its sustainability, low carbon energy and energy efficiency, and environmental infrastructure as well as innovation, taking into account regional disparities.
- To improve preparation and prioritization of large projects and accelerate their implementation.
- To improve the efficiency of public procurement and ensure full and sustainable implementation of the national public procurement strategy.

Under the circumstances described above, in order to assert itself among the top universities to develop a high degree of trust in Romania, but especially in the top of universities that carry out research, innovation, and technology transfer activities at the level of excellence in Europe and in the world, Romanian universities are in fierce competition in accessing various external funding grants, from European (structural funds, Horizon 2020) or international sources (World Bank, other sources), in order to improve their research–innovation and technology transfer infrastructure and to increase its competitiveness in these areas at the highest levels. Of course, in parallel, these infrastructures must be endowed with qualified human resources, which can use the research base (equipment, databases, protocols) at a high level of performance.

For instance, Horizon 2020 is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness. By coupling research and innovation, Horizon 2020 is lending support to achieve this, with emphasis on excellent science, industrial leadership, and tackling societal challenges. The goal is to ensure Europe produces world-class science, to remove barriers to innovation, and to make it easier for the public and private sectors to work together in delivering innovation [32].

From the perspective of the European structural funds, available to Romania (as a member of the EU, starting with 1 January 2007) during its first programmatic period 2007–2013, in the fields of research, innovation, and technology transfer, were EUR 646 million granted by the priority axis "Research, technological development and innovation for competitiveness" and EUR 470 million granted by the priority axis "Information and communication technology for the public and private sectors" [33]. In the programmatic period 2014–2020, EUR 206 million were and still are available through the priority axis "Technological transfer" [34], EUR 894 million through the priority axis "Research, technological development and innovation in support of economic competitiveness and business development", and EUR 630 million through the priority axis "ICT for a competitive digital economy" [35].

This article aims to analyze a particular case study of a top university in Romania, which implemented such a grant financed by European structural funds and created one of the most important advanced research institutes in the horticultural field, not only in Romania but in Central and Eastern Europe, thus creating the premises for research at a European level of excellence and driving the university towards the international entrepreneurial way. For this purpose, the research is conducted as follows: in the following section (Section 2) data are presented about the university that implemented the case study and the implemented research project, whose effects are analyzed from the perspective of five result indicators. The next section (Section 3) contains a detailed analysis of the RDI&TT performance of the newly created institute from the perspective of all horticultural branches, following the five set result indicators. The last section (Section 4) summarizes the

main conclusions on the presented case study, as well as gives a series of recommendations regarding future research in the field.

2. Materials and Methods

The case study was carried out at the University of Agricultural Sciences and Veterinary Medicine in Cluj-Napoca (UASVM), a university with a tradition of over 150 years in the field of agricultural sciences. Thus, in the period 2010–2016, the university implemented the research grant "The Advanced Horticultural Research Institute of Transylvania"—ICHAT, co-financed by the European Regional Development Fund, based on the funding contract signed with the National Authority for Scientific Research as intermediate body (IB), and on behalf of and for the Ministry of Trade Economy and Business Environment as Managing Authority (MA) for the Sectoral Operational Program "Increasing Economic Competitiveness" [33].

Through this project, worth about EUR 15 million, UASVM managed to build a modern research institute with research laboratories dedicated to the main horticultural fields, which can host diversified research (R), development (D), innovation (I), and technology transfer (TT) activities at modern standards. The institute also hosts conferences, participates in national and international activities and events on research topics. To achieve this objectives, the endowment of the institute includes high class equipment and techniques, which should meet the highest national and international standards in the field, in order to increase its research capacity by developing the research–development (R&D) infrastructure and attracting young people as well as highly qualified specialists. Through the objectives established by UASVM, ICHAT became the first advanced horticultural research institute in the country that incorporated all modern horticultural–agricultural fields that are studied in the profile universities, that carries out advanced research in the field of agricultural sciences, in accordance with the newest standards, and that is governed by European policies.

The new institute, in a 4-storey structure, has 46 specialized laboratories dedicated exclusively to research, 23 special warehouses that directly serve these laboratories, 35 researchers offices (small labs for dissemination and data processing), a conference room for the dissemination of research results, a library and a database, an Innovation Research Centre (IRC), indoor greenhouses for applied research, and other necessary technical and administrative rooms. The institute building totals an area of approx. 10,000 sqm, ensuring a layout and a configuration of laboratories that allow an optimal technological flow, but also the development of the activities in a pleasant environment (Figure 1).

Still through the project, the institute was equipped with high-class research equipment and techniques, comprising over 650 items of research equipment, which meet the highest national and international standards in the field. Outside the institute building, two greenhouses have been modernized (vegetables and flowers) for advanced research activities (2158 sqm), these being intended for applied activities. (Figure 2).

The project also included the endowment of the Biodiversity Research Centre, known as the Gene Bank, a unique facility in Romania which serves most of the newly established horticultural laboratories (Figure 1).

The research materials that are used and described in this section are also presented in the above images. Figure 1 presents an emblematic image of the university attesting its antiquity and profile, under the emblem "Tradition and Modernity", the UASVM Central Library of the university which contains both the database (online and offline) that underlies the new horticultural research and the results of horticultural research (and not only) published by our researchers, an image of the Biodiversity Research Centre (Gene Bank) and, finally, an overview of the Advanced Horticultural Research Institute of Transylvania, the basic engine of this scientific article. Figure 2 illustrates a sample of the most important equipment: IRC, amphitheater, vegetable greenhouse, modern magnifying glasses and microscopes, GPS last generation devices, a plotter, an electron microscope and a chromatograph (state of the art), as well as an orchard tractor and installation hail.

Figure 1. Research centers at UASVM Cluj-Napoca. Images taken by the authors.

Figure 2. ICHAT equipment. Images taken by the authors.

On the other hand, as already mentioned, the applied research method is the case study resulting from the implementation of the ICHAT project within UASVM, supplemented with relevant analyses related to RDI&TT activities which were carried out within the new institute and which mark the contribution of our university to the advanced RDI&TT that takes place in the field of horticulture due to a European investment in Cluj-Napoca. The TT method is based on the strong bilateral interaction between UASVM and ICHAT, because this exhibits a more positive and significant effect on scientific performance in both direct and indirect ways compared with the bilateral interactions between research institutes and industries [36], and communication is the medium for building trust and strong social ties [37]. In our case, the TT method includes the 5 result indicators assumed by project implementation in its sustainability period (detailed in the next section).

TT is beneficial for industry because utilizing university-developed technologies can help maintain a comparative advantage in the marketplace and save R&D time and cost, and being affiliated with a university might provide a halo effect for the firm [15,38]. Additionally, firms that collaborate with universities have greater access to new university research and discoveries. Academic–industry collaboration might also provide entrepreneurial opportunities for faculties. Faculties' members have the opportunity to complement their own research by using licensing royalties and other revenues to fund graduate students, laboratory equipment, and other research tools [38–40], but this is not only a formal transmission of science-based inventions, such as the licensing of patented technology to a firm [41], but a dynamic interaction [42]. The best academic entrepreneurs make use of the different university–industry knowledge transfer channels in an entrepreneurial way with a clear long-run valorization strategy in mind [43]. More than that, academic units' alliance management capabilities have a significant positive effect on TT success [44].

TT and innovation are mutually supportive. In this perspective, technology (knowledge) transfer is the key for innovation processes to take place. TT and innovation are two sides of one medal. Innovation is a system that involves different actors: science, firms, government, and the public [45]. Innovation has very important effects on the competitiveness and sustainable economic growth in both the micro economy level and the macro economy level. The WEF Global Competitiveness Index (GCI) defines competitiveness as the set of institutions, policies, and factors that determine the level of productivity of a country. For this reason, it is clear that innovations are very important for the competitiveness of the countries [46,47].

Knowledge and its transference are increasingly viewed as key factors of companies' competitiveness [48]. Research can lead to science-based innovations, which trigger a considerable increase in productivity, new products and services, and improved competitiveness. The business sector can benefit massively from innovation, insofar as innovation strategies are effective, based on public–private interaction, to meet societal challenges. The experiences developed in the market and mentioned in the literature by several authors attest to the fact that only the supply of innovation is not sufficient, the demand for innovation being absolutely mandatory (commercial opportunities). Demand-driven policies are those that can induce investment in technologies by expanding markets for them [49].

The model of I&TT, but also the entrepreneurial approach of R&D activities, are similar in the case of ICHAT, being involved all the actors mentioned in the quadruple-helix concept: academic research, companies, public administration, and society [50,51]. Working together in the research laboratories of ICHAT are the academic staff and researchers of UASVM—Faculty of Horticulture from corresponding departments (about 65 academic staff and about 50 new PhD students every academic year), as well as a series of research specialists employed by ICHAT exclusively in the field of research (8 researchers), especially in transversal laboratories (microscopy, chromatography, spectroscopy). All actors must be fully and responsibly involved, both at the level of demand and at the level of supply (ideas, innovations, services), in order to generate growth and competitiveness in the market (Figure 3). All ICHAT departments are permanently involved in identifying the challenges of the economic and social environment, carrying out applied and market-oriented research, leading to growth (productivity, quality, diversity, support services) and competitiveness.

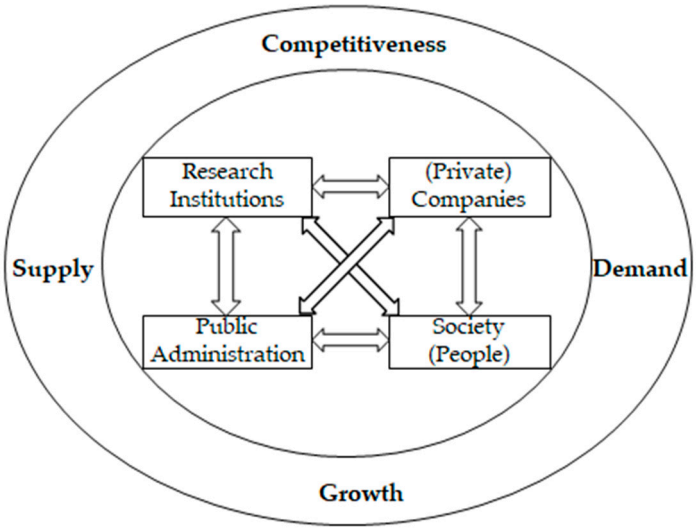

Figure 3. Technology transfer concept at ICHAT-UASVM.

Under these conditions, in Romania, people in the university environment can operate the departments of I&TT, because they are in direct contact with the research in its various forms and can easily realize the mediation contacts, i.e., the interface [5,52,53]. ICHAT also fulfills the role of a Technology Transfer Centre, and in the case of UASVM, the TTO is the Centre for Project Management and Technology Transfer (Figure 4).

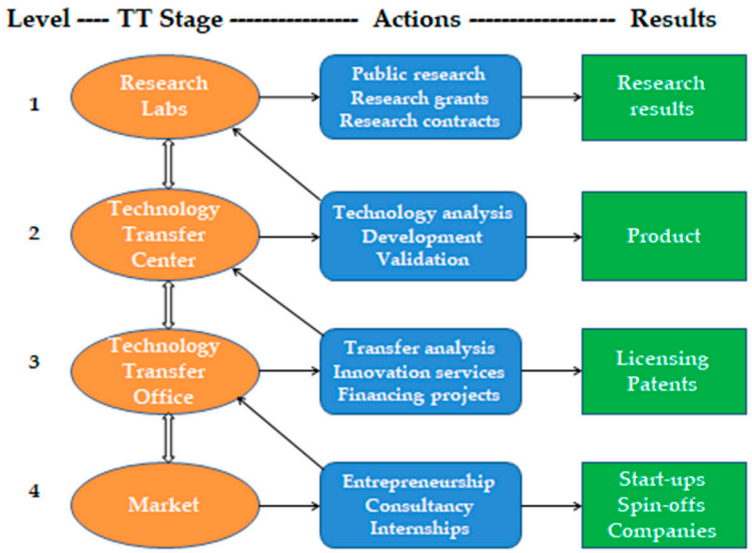

Figure 4. What (should) happen(s) in universities, in terms of technology transfer.

According to U2B Staff Online Business Education (2020), Universities and research institutions have always been the engine rooms of innovation in the world. Starting from a simple idea, a developed concept can very well become the next life-changing invention. Ideas are born all the time. However, developing an idea into a tangible and marketable product requires time, money, and resources. Technology transfer allows this to happen.

Mechanisms of TT include joint laboratories between academia and business, spin-offs, licensing of intellectual property (IP), research contracts, mobility of researchers, joint publications, conferences, expositions and special media, informal contact within professional networks, and a flow of graduates to the industry [14,40]. The authors of [22] also identify sponsored research, hiring of students, and serendipity as other mechanisms of TT. These mechanisms create pathways of TT that do not necessarily have to flow in one

linear direction. These are all important components to consider in illustrating a dynamic view of TT.

Starting from the challenging question: "What (should) happen(s) in universities?", in terms of TT [54], the steps assumed by ICHAT should be the following (Figure 4):

1. Public research, or research funded by grants/contracts, should be carried out in specialized research labs, ending with measurable effective and efficient research results (specific, measurable, accessible, realistic, and temporarily determined);
2. Technology analysis, development, and validation of results should be carried out in specialized technology transfer centers, defining the final product. There are mandatory cost-effective measurements, technology endurance tests, marketing research, resources management, risk management policies, etc.;
3. Transfer analysis, innovation services (maybe using financing projects), should be carried out by technology transfer offices, to facilitate licensing and patents of the product;
4. New entrepreneurial approaches to create start-ups or spin-offs, this should include consultancy and internships from/in mature companies to launch and implement licensed products in the market.

The 21st century university is an entrepreneurial university with a mission of economic development in addition to research and teaching, and an interdisciplinary organizational structure that facilitates knowledge-based innovation [19,22,52,55,56]. A university in which research is routinely scrutinized for both commercial and scientific potential is becoming the prevailing academic institution. The entrepreneurial university takes a proactive stance in putting knowledge to use and in broadening the input into the creation of academic knowledge. Thus, it operates according to an interactive rather than a linear model of innovation [15,57]. Innovation is a specific function of entrepreneurship. Entrepreneurial organizations value and nurture innovation because this is the key to ensuring adaptability. Therefore, it is argued that universities need to adopt an entrepreneurial approach if they are to fulfill their mission and role in society [19,58]. Such universities have the internal capabilities to translate research results into intellectual property and economic activity. It seems that technology transfer will become more important to economic development over time. Through technology transfer, universities contribute to the stock of technical knowledge and technologies that firms can draw on for innovation and hence economic growth [8,22].

UASVM is currently on its way to growing evidence of its entrepreneurial character, because the responsibilities and tasks of the university have been extended. The two traditional key functions of the university—academic education and academic research—have been extended by the last few years' mission to include a third key function: creating value for society. According to [9], there are two targets: increasing the societal responsibility of the individual researcher and the university as a whole, and stimulating economic factors to assure the continuity of the research organization. This also means that a deeper connection of the university to the challenges and expectations of society, or to technological development trends, adaptation of research protocols to market demand, orientation of research to the needs of companies and the population, intensified communication with other actors of technology transfer, development of communication networks, and licensing and patenting of intellectual property are now becoming an important asset of UASVM and will become an important indicator for success in the near future.

3. Results and Discussion

The main disciplines in the field of horticulture, brought together by the new advanced research institute, are vegetable growing, floriculture and landscaping, ornamental arboriculture, fruit growing and pomology, viticulture (including ampelography and oenology), horticultural products technology, genetics and plant breeding, microbiology, horticultural biotechnologies, and land and cadaster measurement. Apart from these, other cross laboratories were considered to serve more horticultural fields: spectrometry, chromatography, electron microscopy, but also the gene and seed bank.

In this section, we will present how the new institute contributed to the development of research, development, innovation, and technology transfer capacity in the north-western region of Romania through the lens of 5 result indicators recorded over a sustainability period of 5 years (2017–2022):

- New jobs created in the R&D field thanks to the project (researchers and PhD students);
- Jobs maintained in the R&D field due to the project (researchers and PhD students);
- The private contribution (eligible and ineligible) of the university to the project;
- International projects in which the new infrastructure was involved;
- International events in the field of RDI&TT hosted or facilitated by the new infrastructure (conferences, symposia, congresses, networking, matchmaking, etc.).

These 5 result indicators were agreed on together with the National Authority for Scientific Research in the interest of the European Authority for Scientific Research.

In Transylvania (north-western region of Romania), as a result of the abolition of the Vegetable Resort Arad (western region of Romania) and the restriction of the activity of the Resort Iernut (central region of Romania), possibilities for extension, improvement, and deepening of research in vegetable growing, of zonal and national interest, exist within the specialized team, in the conditions of ensuring modern spaces and technical endowments at the level of the current and perspective exigencies. The newly created situation allowed the implementation of advanced research of great economic and social importance at present and in the perspective of the following years, such as:

- The biodiversity of species and vegetable varieties were maintained and expanded, because in the area there are important genetic sources of onion, garlic, cabbage, beans, radishes, and other greens (stevia, perennial onions, lamb's lettuce etc.);
- Special technologies have been developed corresponding to the principle of sustainable agriculture in the field of vegetable growing, a field not previously addressed in our country, such as: unconventional soil works, the influence of compatibility or incompatibility phenomena (allelopathy) in crop rotation, successive and associated crops;
- New cultivation technologies of the main vegetable species have been implemented in ecological systems (substrates, fertilizers, protective measures).

The research on the culture of vegetables on different substrates has been extended and deepened to give them greater security, through a more rigorous control over nutrition and cultural hygiene. Reducing the attack of soil diseases and pests, which was previously performed with high costs, poor results, and negative effects on environmental protection, is now easier through crops "without soil". The new labs have opened up research possibilities in other fields, such as crop fertilization, study of allelopathic influences in crop rotation, in associated–intercalated or successive crops, and the influence of the minimum of soil works on vegetable production; aspects that have been little researched before, but which capitalize more technology transfer in vegetable field, having a capital importance in substantiating the cultivation technologies regarding the concept of "sustainable agriculture" and obtaining "healthy", organic products. The most relevant research projects implemented in the field of vegetables are in Table 4 below:

In the field of floriculture, in the last years Romanian people have witnessed more and more the increase in the consumption of dendro-flowering plants but also the emergence of new private companies that are interested in business, sustained massively in the last years with the support of the European grants. In this sense, the new institute ensures a varietal palette by diversifying an assortment of flowering plants resistant to pollution, or other valuable flowering and little known plants in our region, or even new varieties, in order to maintain an ecological balance in Romania, by their use in different landscaping schemes. Thus, annual, biennial, and perennial decorative flowering plants were introduced, which represent a unique decoration in every season. Based on the observations and determinations regarding the main morpho-decorative characteristics, the behavior of these new species, varieties, and hybrids of flowering plants in the conditions of Transylvania, their

productivity and resistance, as well as the perspectives for their implementation in green spaces, for interiors, and as cut flowers are highlighted.

Table 4. Vegetables—research projects.

Project Title	Funding Source	Project Amount	Period
Solarvibes—Revolutionizing IoT Scalability in Agriculture	H2020-IOT-2016	EUR 75,000	2019–2021
Diversification of the assortment of vegetables processed by lactic fermentation using different selections of lactic bacteria	private research contract	EUR 15,000	2021–2022
Tomato program—microproduction	National funds	EUR 5000	2019–2020
Study on the traditional and innovative methods of determining the efficiency of the vegetable growing activity from the perspective of the accounting—management relationship	private research contract	EUR 15,000	2021–2022

Source: Based on https://horticultura.usamvcluj.ro/proiecte/ (accessed on 25 March 2023).

The creation of the tropical plant collection was initiated at UASVM from the establishment of the Faculty of Horticulture (1990), but it reached small dimensions until the appearance of ICHAT. That is why the current scientific research is directed towards the diversification of this collection and towards the increase in the adaptation process by applying different agrotechnical methods, the creation of favorable conditions for the development and the generative multiplication through seeds and vegetation. There are studies on the particularities and the way of research and maintenance of some precious collections of cacti, succulents, bromeliads, etc.

Research regarding the exploration of the spontaneous flora carried out by the bilateral contract between UASVM and South Korea are being materialized by introducing species of great national, but also worldwide interest, such as those of the genus Scutellaria or other flowering plants which also have medicinal or aromatic effects into the culture of native species in Romania.

The experience already gained in the research contracts developed at UASVM, regarding the creation of new varieties, and the homologation of gladiolus, gerbera, and carnation varieties, created the opportunity to continue the research and selection of new hybrids for homologation of new Romanian varieties, which are competitive worldwide, increasing innovation and TT in floriculture.

Additionally, the new research institute allowed to approach the following aspects:

- Studying and recommending new growth regulatory substances, combining in vivo and in vitro propagation techniques to increase the productivity and quality of planting material;
- Monitoring some aspects of nutrition and fertilization in the ecological system in floricultural and dendrological crops;
- Elaboration of technological sequences for obtaining the seeding, flowering and dendrological material free of viruses, mycoplasmas from the pre-base, base, and certificate category;
- Development of research in the field of modern biotechnologies, molecular biochemistry, phyto-protection, and floral physiology;
- The monitoring of soil quality elements and the use of modern and efficient crop substrates in floricultural and dendrological crops;
- Using the most modern methods of watering and monitoring, and warning of watering moments in floral and dendrological crops;
- The control of weeds by using the floral plants with allelopathic effects and biological products.

Complementary to the activities described above, the most significant research projects implemented in the field of floriculture are presented in Table 5 below:

Table 5. Floriculture—research projects.

Project Title	Funding Source	Project Amount	Period
Technology transfer of in vitro propagation of Lonicera caerulea species	III National Research Program	EUR 10,000	2017
The development of an acclimatization sector and the transfer of the ex vitro rooting and acclimatization technology of the Aronia melanocarpa species	III National Research Program	EUR 10,000	2017
The comparative evaluation of conventional and conservative tillage systems regarding carbon sequestration and foundation of sustainable agroecosystems	III National Research Program	EUR 10,000	2017
The integration of green infrastructure in urban and peri-urban landscape through sustainable spatial planning	III National Research Program	EUR 15,000	2017
Anthropogenic gadolinium as a potential micro-contaminant of the environment: Phytotoxicity study on Stevia rebaudiana grown in vitro	III National Research Program	EUR 90,000	2020–2022

Source: Based on https://horticultura.usamvcluj.ro/proiecte/ (accessed on 25 March 2023).

From an ornamental arboriculture perspective, the following additional clarifications are important:

- Research on biomass accumulation and vegetative growth of woody species of ornamental interest is carried out;
- The new institute includes the only modern laboratory in the region for seed quality analysis;
- The ways of reproduction (sexual or asexual) of trees and shrubs of ornamental interest are studied;
- Determinations and studies are performed on the influences of external abiotic factors on the growth and development of ornamental species;
- Research is carried out on the diagnosis of phytopathogenic agents that affect ornamental wood species;
- In the laboratories newly created by the project ornamental varieties of special value are created and homologated.

So, the most relevant research projects implemented in the field of ornamental arboriculture are presented in Table 6 below:

Table 6. Ornamental arboriculture—research projects.

Project Title	Funding Source	Project Amount	Period
The socio-professional network for improving the quality of life in the urban environment in Romania	LAN-NET	EUR 75,000	2017
Services of investigation and diagnosis of the dendrological material within the radius of the Municipality of Bucharest	private research contract	EUR 20,000	2021
Study on assessment of existing forest management models and recommendations for climate-smart forest measures (natural hazards)	private research contract	EUR 10,000	2021–2022
Services for the protection of the urban landscape by establishing the method of intervention on the trees notified/requested for approval, located on the lands/green spaces within the radius of the Municipality of Bucharest	private research contract	EUR 30,000	2021–2022

Source: Based on https://horticultura.usamvcluj.ro/proiecte/ (accessed on 25 March 2023).

Regarding fruit growing and pomology, the new institute provides separate laboratories of fruit techniques and technologies, micro-propagation, phytosanitary protection, and post-harvest technologies. The mentioned laboratories created the premises for

- Carrying out modern and sustainable fruit activities in the conditions of Transylvania and increasing the quality and food safety by increasing the competitiveness of

technologies for obtaining fruit products, with an impact on environmental protection, quality of life, and sustainable economic development;
- Intensifying the process of concentration and higher valorization of the high-level scientific and technological potential through the multidisciplinary approach to the research themes;
- Increasing the capacity of the complex teams of researchers, in order to increase the knowledge in the scientific and technological fields, the accumulation of results and experience, to disseminate them in fruit-growing units;
- Identification of the air–plant–soil mechanisms that determine the exploitation of the productive potential of each variety at the highest level.

The virology department provides the scientific experience and the facilities necessary to guarantee the health of the planting material from the viral point of view. One of the important activities is the production of planting material, free of pathogenic viruses and other viral agents, in order to provide healthy, safe, and high-quality plants.

The research activity of the laboratories is oriented towards the creation and selection of high-performance rootstocks for the apple species and the modern and fast methods of obtaining the fruit sowing material, in accordance with the requirements of the EU. Within the laboratories, the initial material from the biological categories pre-base and base is multiplied, which is necessary for the establishment of planting material of mother plantations supplying rootstocks, cuttings, and graft branches to the producers. This also contributes massively to the transfer of technology in the field of pomiculture. The most important research projects implemented in the field of pomiculture are presented in Table 7 below:

Table 7. Pomiculture—research projects.

Project Title	Funding Source	Project Amount	Period
The implementation of some agro-pedo-ameliorative technologies in the culture and production of planting material for cultivated blueberry (Vaccinium corymbosum)	III National Research Program	EUR 10,000	2017
Keeping in quarantine some plants of the Prunus species to prevent the spread of organisms harmful to plants or plant products in EU	private research contract	EUR 10,000	2017
The study of the genetic diversity of pear resources (Pyrus sp.) from China and Romania and the use of in vitro micropropagation techniques for the conservation of the germplasm pool	III National Research Program	EUR 10,000	2018–2019
Development of local markets exclusively through short chains for sea buckthorn	EU structural funds	EUR 100,000	2020–2022
Identification and study of new hazelnut varieties, development of a new horticultural product for the domestic and European market	EU Structural funds	EUR 120,000	2022–2024

Source: Based on https://horticultura.usamvcluj.ro/proiecte/ (accessed on 25 March 2023).

The implementation of the new horticultural institute allows the realization of research projects, in viticulture as well as in ampelography and oenology, such as:

- Research on the evolution of wines from different wine-growing areas during preservation and maturation;
- Physical changes and biochemical transformation in grapes into different varieties during preservation under controlled environmental conditions;
- Research regarding the influence of physical and chemical properties of soil on the development of the root system and the vigor of growth on different varieties of vine;

- The influence of eco-climatic and eco-pedological conditions on the content of macro and micro elements in the green organs of the plant;
- Methods of production of vineyard material according to European standards;
- The availability of local varieties for the conditions in the center and west of the Transylvanian Plain;
- Research on morphological characters and biotechnological attributes of autochthonous vine varieties, grown in the Transylvanian region using the ampelographic codes;
- Separation and dosing of the main plant pigments present in different grape varieties (flavonoids, anthocyanins, chlorophylls);
- Determination of grape compounds with antioxidant effect (polyphenols, catechins, etc.);
- Using the laboratory for determining the quality of the wines according to the requirements of the European Union.

In addition, the tasting room offers the possibility of organizing national and international tasting competitions, through retails or direct participations, as well as the appreciation of all products from different producers, generating winnings. Among the specific projects that are considered, it can be mentioned (Table 8):

Table 8. Viticulture—research projects.

Project Title	Funding Source	Project Amount	Period
Intelligent viticulture pilot—Decisional Support for the Prevention of Grapevine Blight	III National Research Program	EUR 10,000	2017
Identification of the factors determining the occurrence of bacterial cancer (Agrobacterium tumefaciens) in some varieties of grapevines, in a few viticultural centers, and the development of disease control strategies	private research contract	EUR 15,000	2017–2018
Biodiversity-based ecosystem services in vineyards: analysing interlinkages between plants, pollinators, soil biota and soil erosion across Europe	III National Research Program	EUR 87,000	2017–2019
Supporting scientific research and development activities in the field of horticulture through the development of modern technologies for vine management, cutting and palisade, with the aim of increasing the production and quality of viticultural products	private research contract	EUR 10,000	2017–2019
Data integration to maximise the power of omics for grapevine improvement	COST		2018–2021
Scenarios for ensuring multiple ecosystem services and biodiversity conservation in viticultural agroecosystems	ERANET	EUR 150,000	2019–2022

Source: eco-pedological https://horticultura.usamvcluj.ro/proiecte/ (accessed on 25 March 2023).

The research field "Horticultural product technology" is very complex and diversified, incorporating, in a synthetic framework, all the theoretical and practical knowledge regarding the transport, storage, and semi-industrialization or industrialization of horticultural products. At the same time, it is one of the horticultural branches that has extremely much to gain from the fact that the new institute concentrates all horticultural fields in one place, which allows the centralization of data that can be used in research and implemented in the productive sector. Thus, comparative studies can be made on the chemical composition, nutritional value, biological value of finished products (juice, syrup, jam, jam, vegetables preserved in various forms), obtained from organic raw materials—from spontaneous flora (raspberries, blackberries, blueberries, eglantine, sea buckthorn) to materials obtained from industrial crops.

The most significant research projects implemented in the field of horticultural product technology are presented in Table 9 below:

Table 9. Horticultural product technology—research projects.

Project Title	Funding Source	Project Amount	Period
Development of local markets exclusively through short chains for mountain fruit products	EU structural funds	EUR 10,000	2017–2019
Sustainable exploitation of tomato processing industry by-products	ERANET	EUR 118,000	2017–2020
Nutritional optimization of food products based on grapes and forest fruits, by enrichment with Resveratrol, for the purpose of intensifying the supply of antioxidants in food	EU structural funds	EUR 1,200,000	2018–2023
Innovative extraction methods for the characterization of food plants and by-products as valuable sources of nutraceuticals	III National Research Program	EUR 125,000	2020–2022
Development of innovative nano-systems to improve the physical-chemical properties, bioactivity and stability of essential oils	III National Research Program	EUR 250,000	2021–2023

Source: eglantine https://horticultura.usamvcluj.ro/proiecte/ (accessed on 25 March 2023).

Genetics and Plant Breeding have profoundly influenced all human activities. Most of our foods come from genetically improved organisms. Genetic research has changed man's position in relation to the organic world and the rest of the universe. Along with genetics, plant breeding had and has a great practical significance. The multitude of vine varieties, trees, fruit trees, and vegetables, obtained and cultivated in Transylvania from ancient times to the present day, and the variety changes that have taken place over time, illustrate the concerns and results obtained in the field of plant breeding on these lands.

Although many horticultural species are genetically very diverse, the varieties of cultivated species have a fairly limited genetic base, a continuously narrowed genetic pool, due to the selection made over time. As a result, many horticultural species can always be vulnerable to a catastrophe (the emergence of new pathogens or pests, increases in the virulence of the attack of the existing ones, the conditions of the continuous intensification of the cultures, the climate change, the pressure of the selection, etc.), the risk being emphasized by the limitation of the genetic resources used for improvement in recent times. Therefore, it is necessary to enrich the germplasm fund in horticultural plants and to establish conservation methods, to develop methodologies for the phenotypic, genotypic, and molecular evaluation of genetic resources for their efficient use in the future for the benefit of humanity, as well as to obtain and promote a biological material with a heterozygous genetic structure through which our country contributes to the world efforts, in order to diversify the assortment and to avoid crisis situations in the culture of the most important horticultural species.

The new institute undoubtedly contributes to the development of knowledge in the field of genetics and improvement in horticultural plants, even if in recent years research on biodiversity conservation and creation of new varieties has decreased in intensity, amid land and economic problems but also due to specialty staff, who were confronted by the research units in which improvement works are still carried out (institutes and resorts, universities of agricultural sciences).

Within ICHAT, the development of these disciplines allows the approach and solution of extremely complex problems represented by the conservation of genetic resources for horticultural species, the improvement of native genotypes, and the creation of new cultivars with ecological plasticity, and resistance to stress factors, diseases, and pest attacks.

At the same time promoting the development of the implementation mechanisms of the new achievements, or creations, in production and technological processes. The main research projects implemented in the field of genetics and plant breeding are presented in Table 10 below:

Table 10. Genetics and plant breeding—research projects.

Project Title	Funding Source	Project Amount	Period
Research on the structure of hybrid populations of the heredity of characteristics and genetic determinism in fruit tree species	National Research Program	EUR 20,000	2017–2018
Management of fruit genetic resources in situ and ex situ	National Research Program	EUR 8000	2017–2018
Transfer of the protocol for extracting residual DNA from wines in order to authenticate them through genetic fingerprinting	III National Research Program	EUR 10,000	2018
Ecosystem services provided by soil biological diversity—understanding and management	ERANET	EUR 136,000	2017–2020
Development of novel breeding technology for improved root system, drought tolerance and sustainable plant productions	ERANET	EUR 200,000	2021–2022
Research on obtaining a consortium of microorganisms useful in horticulture	private research contract	EUR 10,000	2022

Source: Based on https://horticultura.usamvcluj.ro/proiecte/ (accessed on 25 March 2023).

Through microbiology, micropropagation, and germplasm conservation laboratories of economic interest the new horticultural institute has achieved two important goals: first, the establishment of an in vitro multiplication unit for the production of horticultural seeding material, a unit specialized to European standards. The second goal is to maintain a collection, coordinated regionally, of genetic resources of economic interest, which optimally represents the genetic diversity currently known, designed to ensure preservation and facilitate access to a specific gene pool; a collection that will permanently provide material required for characterization and improvement assessment. This goal is being achieved through three main categories of activities:

1. Collections in free space, controlled, made by sowing with certified seedlings, multiplied in vitro;
2. Maintaining a plant material fund, through in vitro cultivation of selected genotypes;
3. Initiation of a specialized gene bank.

The seedling material, represented by the seeds itself, the somatic embryos encapsulated, or the plantlets obtained using micropropagation, is preserved in situ and ex situ, by keeping certain species on the original land, and in the micropropagation unit collection (gene bank). By developing close relationships with other institutes or research and multiplication of forest species, the biological material is also received from them. This source ensures the conservation of biodiversity, thus reducing the conflict of interest due to the research institute's desire to conserve a species over a short period, as much as it brings limited scientific interest (the duration of a research contract).

The most common economic and technological transfer activities brought by using the micropropagation unit are: collecting and regenerating seedling material, seedling documentation, user information services, seed management, performing viability tests on the seed, distribution, and evaluation of genetic material collections. In our micropropagation unit, the material intended for in vitro multiplication and preservation is provided, to a large part, by growers. Thus, it represents the selected genotypes of some forms easily

adaptable to the area exactly intended. Being dynamic, these cultures change as needed, outdated forms being annually removed.

Applications for seedling material appear in the public, private, and civil sector (a concrete example of quadruple helix operation). Customers want the genetic material for breeding, for classical research, introduction and reintroduction of genetic material into horticultural areas, and to search for some genes of interest. Researchers are interested in the adaptive traits incorporated into the multiplying material, that can be represented by elite lines or their distant forms, while the effective exploiters (farmers) demand the variants adapted to similar ecosystems. Anticipating the purpose of using the genetic material determines how it is preserved: as a specific genotype or as a population in which a particular genotype is not fixed along generations.

The most relevant research projects implemented in the field of microbiology are presented in Table 11 below:

Table 11. Microbiology, micropropagation, and germplasm conservation—research projects.

Project Title	Funding Source	Project Amount	Period
Optimizing and testing the in vitro propagation technology for two chokeberry varieties and providing consultancy for the production of chokeberry planting material obtained by micropropagation	private research contract	EUR 10,000	2017
Modifying plants to produce interfering RNA	COST	EUR 10,000	2018
Transfer of in vitro propagation technology of some cherry rootstocks	III National Research Program	EUR 10,000	2018
Micropropagation laboratory optimization	III National Research Program	EUR 100,000	2017–2022
Optimization of micropropagation protocols for the production of planting material for new species of economic interest	domestic funds	EUR 10,000	2019
In vitro multiplication of 2250 pots with in vitro cultures of thornless blackberry, Chester and Lochness varieties	private research contract	EUR 10,000	2019–2021
Technology and system with temporary immersion in bioreactors with digital control, intended for micropropagation of plants	III National Research Program	EUR 60,000	2020–2022
Adaptation and optimization of the super-intensive ecological culture system of strawberry in protected areas	private research contract	EUR 150,000	2021–2022

Source: Based on https://horticultura.usamvcluj.ro/proiecte/ (accessed on 25 March 2023).

From the horticultural biotechnology perspective, the new institute proposes an interdisciplinary approach comprising scientific aspects of the production and monitoring of GMOs (genetically modified organisms), as well as social–economic assessments of environmental and consumer health impacts. The objectives of the institute are within the priority areas of agriculture, such as: sustainable development, ecological systems, knowledge, and control of global change, and have been considered in the perspective of the problems proposed for solving, related to the current situation of the field and the projects theme:

- The development of experimentation and evaluation of the degree of risk model, by removing two species in the field (one allogame and one autogame) of genetically modified plants;
- The foundation of a center of excellence as the regional basis of services for scientific information, consulting, coordination, and access to national and European legislative documentation in the field of biotest, bio-protection, and bio-security;

- Setting up a training program for specialist consultants (assessing experts for GMOs), according to the rules and methodology required by the European Union.

The institute's activities cover several thematic areas, of which the most important are

- Potential natural and anthropic hazards: protection systems;
- Structure and functional role of biodiversity;
- Invasive alien species: substantiating prevention and control means;
- Natural and semi-natural ecosystems: productive and resilient capacity;
- Designing, management structure, and dynamics of local and regional socio-ecological complexes in the context of national interest.

The research projects implemented in the sustainability period prove that the proposed objectives have already been achieved (Table 12):

Table 12. Horticultural biotechnology —research projects.

Project Title	Funding Source	Project Amount	Period
Innovative ex-situ bioremediation technology of hydrocarbon-polluted soils	III National Research Program	EUR 45,000	2017–2018
Functional collaboration model between public research organizations and the economic environment with the aim of providing high-level scientific and technological services in the field of bioeconomy/Project 1: The influence of environmental conditions, biological and technological factors on the quantity and quality of soybean production	III National Research Program	EUR 20,000	2018–2019
Eco-nano-technologies and intelligent equipment for the mapping of soil properties and the assessment of plant dynamics, in order to improve the efficiency of agricultural production and environmental protection	III National Research Program	EUR 20,000	2018–2021

Source: Based on https://horticultura.usamvcluj.ro/proiecte/ (accessed on 25 March 2023).

The specialists of the Land and Cadaster Measurement (LCM) appreciate that the soil degradation affects agriculture to a high degree, as well as other fields of activity, contributing directly to the pollution of the environment. Additionally, it is appreciated that, annually, over 76 billion tons of fertile soil is lost through global erosion, of which approximately 23 billion tons lack the capacity to recover new layers [59].

The impact of erosion on the soil cover, agricultural production, ecological balance, etc., is a priority for our country. The land of Romania is covered with a very varied mosaic of soils that have formed and evolved into a wide variety of local conditions under a strong anthropic influence. To the great diversity of soils the differing conditions of placement of agricultural use are also added. Thus, 50% of the arable land, 60% of the vineyards, and 70% of the tree plantations, are situated on sloping land, favoring the processes of soil degradation through erosion and sliding. It is not possible to conceive the development of modern sustainable agriculture in the sloping land area without investigating and adequately solving the erosion processes and the impact they have on the environment, but also the social–economic impact produced by human settlements. Erosion processes are considered intense in our country, with an annual average of 16.3 t/ha per year, placing Romania among the countries most affected by erosion in the EU [60].

A synthetic analysis of the soil erosion map in Romania points out that, at the end of the 20th century, about half of the agriculture land was affected to a lesser or greater degree by the erosion process. More recent data notes the extremely worrying extension of the areas in danger. As a result of multiple natural and artificial causes, among which are rainfall, temperature oscillations, soil type, and especially man's often unwanted intervention (intervention favored by excessive landslide in small plots, where the works are usually

executed without respecting the minimum erosion prevention rules), the areas affected by erosion have considerably increased in recent years in most of Romania's counties.

The main research objectives the LCM has set in the context of the ICHAT are the following:

- Development of methods and methodologies in order to extract the useful parameters from the data provided by the spatial platforms in horticultural applications (fruit growing, viticulture, vegetable growing or floriculture) in the Transylvania area;
- The implementation of a geographical information system (GIS) based on cartographic data and remote sensing, in order to manage the natural resources (climate, hydrological, pedological) in the horticultural areas of Transylvania;
- Making updated digital maps of land cover/use, as well as different thematic maps, with multiple possibilities of visualization, analysis, and interrogation, necessary for the development and exploitation of the horticultural sector in Transylvania;
- Estimation of agro-meteorological and biophysical parameters of the vegetable coating derived from satellite data: the surface temperature of the soil, the real evapotranspiration, foliar index, biomass, spatial structure, vegetation indices (correlated with the vegetation and phytosanitary status of horticultural crops, etc.);
- The realization of a digital altitude model (DAM) of the land and derived products (slopes, exposures, altitudinal floors, topographic profiles, etc.), necessary for the design works and the exploitation of the horticultural sector;
- Developing a management system of spatial databases, derived from satellite information, GPS or terrestrial, dedicated, thematic, as support in facilitating decisions on the regional development of horticulture, attracting investors, or even for elaboration of social–economic analyses;
- Development and testing of methods and spatial data fusion algorithms, from different data sources (remote sensing systems, cartographic documents, terrestrial observation systems, etc.);
- Creating a regional Web GIS portal for horticulture;
- Offering expertise, technical assistance, and consulting for horticultural works, executed by state and private firms, from the country or even from abroad;
- Determining technical parameters of behavior over time of some hydro-material works, with topographic and photogrammetric equipment and high-performance software.

As a consequence of these high objectives, in the first 5 years of ICHAT's existence a few relevant projects were implemented, the main relevant being in Table 13 below:

Table 13. Land and cadaster measurement—research projects.

Project Title	Funding Source	Project Amount	Period
Creation of an integrated GIS system in order to streamline cadastral works	III National Research Program	EUR 10,000	2017
LAND Management: Assessment, Research, Knowledge Base	H2020	EUR 39,000	2017–2018
Soil organic matter—the factor of transformation, productivity and sustainable development in plant-soil relationship	RO-PL Academy of Sciences	EUR 2000	2017–2018
Drylands facing change: interdisciplinary research on climate change, food insecurity, political instability	COST	EUR 10,000	2017–2021
Creation of a GIS database with the situation of tabulated lands at the level of Maramureș county	private research contract	EUR 10,000	2021–2022

Source: Based on https://horticultura.usamvcluj.ro/proiecte/ (accessed on 25 March 2023).

In addition to the research projects developed within the previously described laboratories, ICHAT was also involved, complementary, in the implementation of transversal projects in the field of horticulture, which increase the impact of the specific ones,

both through the associative–multiplicative nature of the R&D field and through the entrepreneurial character, which on the one hand contributes significantly to the intensification of technological transfer (academic–economic collaborations) and on the other hand to the improvement of the entrepreneurial experience of the university. Table 14 below shows some of the most important transversal projects:

Table 14. ICHAT—transversal projects.

Project Title	Funding Source	Project Amount	Period
Start-up Plus in North-West Region of Romania	EU structural funds	EUR 800,000	2017–2021
Learn2Do4 Entrepreneurship	EU structural funds	EUR 150,000	2017–2021
High Nature Value Farming: Learning, Innovation and Knowledge	H2020	EUR 100,000	2017–2019
Innovative and sustainable intensification of integrated food and non-food systems to develop climate-resilient agro-ecosystems in Europe and beyond	III National Research Program	EUR 165,000	2017–2019
CEO Entrepreneur—Competitiveness, Excellence, Opportunity	EU structural funds	EUR 385,000	2019–2021
Competitive education and training in the labor market	EU structural funds	EUR 300,000	2019–2021
Horticulture—creativity, passion and career	World bank	EUR 150,000	2019–2022
Innovative education for sustainable development in peripheral rural areas	Hellenic National Agency	EUR 20,000	2020–2022
European Network to promote grazing and to support grazing-based farms on their economic and ecologic performances as well as on animal welfare	Horizon 2021	EUR 73,500	2022–2023

Source: Based on https://horticultura.usamvcluj.ro/proiecte/ (accessed on 25 March 2023).

Cumulating the research projects implemented within all ICHAT research laboratories, the result is the involvement of the institute in over 60 projects implemented in a period of 5 years, with a total value of over EUR 5.5 million, from national and international funding sources, with dozens of partners from Romania and the EU (the 4th indicator).

The first three proposed indicators are obtained directly from the Human Resources and Financial Accounting Departments of the university. Due to the project:

- A total of 281 new jobs in the R&D field were created: 5 researchers (1 expert in microscopy, 1 expert in chromatography, 1 expert in spectrometry, 1 expert in microbiology, 1 expert in horticultural biotechnologies) and 276 PhD students (167 in agronomy, 48 in horticulture, 48 in biotechnology, 13 in engineering and management in agriculture and rural development, according to the doctoral accreditation fields of the university);
- A total of 440 jobs were maintained in the R&D field (about 200 researchers and 240 PhD students);
- The private contribution (eligible and ineligible) of the university to the project was about EUR 2 million from the general budget of the university.

ICHAT is the first research institute in the university's history to be built with EU funding, has its own management, subordinate to the vice-rector with research at the university, and its own scientific council. As expected, the implementation team of each research project is made up of experts in accordance with its objectives and the specific activities to be implemented.

The 5th proposed indicator can be easily calculated by consulting the website https://www.usamvcluj.ro/ (accessed on 25 March 2023), that includes all the milestones and achievements linked to all the actions in the field of horticulture and related fields. Thus, every year, the institute hosted the "Life Sciences for Sustainable Development" International

Symposium, the Student Scientific Symposium, the Biodiversity of Landscapes Conference, the Bioterra Conference, the Conference of the National Plant Protection Society, etc., as well as distinct events such as the International Conference IENE 2022 (Infrastructure and Ecology Network Europe), PRIA-Agriculture Conference and Transylvanian Farmers Gala 2022, etc., summing up dozens of international events in the field of RDI&TT.

In Table 15 below, a summary of the five proposed performance indicators is presented, to highlight the relevance of the ICHAT institute to the R&D investment made by UASVM:

Table 15. ICHAT performance indicators during the 5 years of sustainability period.

Title of the Indicator	Value
New jobs created in the R&D field thanks to the project (researchers and PhD students)	281 (5 + 276)
Jobs maintained in the R&D field due to the project (researchers and PhD students)	440
The private contribution (eligible and ineligible) of the university to the project	>2 mil EUR
International projects in which the new infrastructure was involved	>60 projects >5.5 mil EUR
International events in the field of RDI&TT hosted or facilitated by the new infrastructure	>30

4. Conclusions

Analyzing the impact the horticultural field brought through the 46 labs, both individual and as a whole, in terms of objectives and results described above, it can be appreciated that both at the level of research excellence and at the socio-economic level, the ICHAT capacity for research, innovation, development, and technological transfer is particularly high, thanks to the successful implementation of a project with European funding. A few examples:

- New jobs were created in the local economy. It also allows young teachers or PhD students to develop skills for new jobs, such as the sommelier work;
- The university visibility was improved at the European and the international level;
- the local, regional, and national business environment was boosted by innovative solutions studied and developed in the institute, to face the new society challenges;
- The level of sustainability of the university was increased by implementing new projects with external funding;
- the evaluation of the germplasma fund, as well as the possibilities for its use in new improvement works, are problems of world interest and perspective, and the complexity of the solutions and problems should be addressed through a modern, multidisciplinary concept, provided by specialists in genetics, improvement, biotechnology, fruit growing, viticulture, vegetable growing, floriculture, physiology, biochemistry, plant protection, management, marketing, biostatistics, computer science, and communication networks, etc.;
- With a modern technical–material base, UASVM has at the highest level the necessary capacities to fulfill the desideratum of modern research in providing food resources, bio-conservation plant resources, the creation of genotypes adapted to climate change, and quality ecological food through the prism of healthy fruits, vegetables, free of toxins and pollutants. In this way, it promotes sustainable agriculture, reducing soil and environmental pollution, and increasing food quality and safety.

Beyond the benefits that each department or research lab brings, maybe the greatest gain of this institute is that it brings together all horticultural areas in a single research institute, thus creating the possibility to support and develop a unitary research process in all fields, streamlining the flow of research, exploiting the character of interdisciplinary at both the didactic–applied level and the level of research, and, thus, the institute can represent a valuable pole in the horticultural research, located in the middle of Transylvania, being able to clog around all the other research institutes in the region.

Taking the conclusions and future mandatory challenges for Romania [29] as guideline, but also the specific investment recommendations for Romania stressed by the European Commission [31], it can be considered that the ICHAT project is a successful achievement on the European recommendation line, implemented in a university situated in the most important university center in Romania and a significant university of Central and Eastern Europe.

An important direction of action for the future is the hiring of new staff, a perspective for scientific research, a higher education, and economic agents, which can meet the future challenges of humanity. Based on the recognition of the horticultural research, the teachers and researchers from Cluj, the results of their work and the achievements in the field of horticulture, this institute has all the premises that, in a short time, it will be affirmed internationally.

On the other hand, an important challenge for Romanian universities still remains: to create and maintain spin-offs and start-ups in the market based on universities' results and innovation. UASVM has currently a huge chance for this, at least in the horticulture field, using the facilities of the new institute (ICHAT).

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