CHALLENGES AND OPPORTUNITIES FOR THE EU CENTER OF EXCELLENCE IN PLANT SYSTEMS BIOLOGY AND BIOTECHNOLOGY IN PLOVDIV, BULGARIA

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Abstract: The Center of Plant Systems Biology and Biotechnology (CPSBB) is the first Bulgarian Center of Excellence (CoE), funded under the Horizon 2020 program, operating in Plovdiv. This article presents a case study that analyses the development of CPSBB over six years. Content analysis was used as the primary research method, focusing on financial indicators, publication and project activity, and human resources development of CPSBB for the 2017-2023 period. The study examines three critical dimensions of sustainability: management, internal and external factors affecting the Center's operation. The analysis supports the hypothesis that organisations such as CPSBB hold a prominent position in Bulgaria's and Europe's scientific ecosystem because of their operational agility and high productivity. The article outlines the execution of CPSBB's development strategy and highlights plans for enhancing the Center's administrative efficiency and long-term sustainability.

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Introduction

The Center of Plant Systems Biology and Biotechnology was established as an independent legal entity in 2015 under Horizon 2020-WIDESPREAD-1-2014- GA-664620. In 2017, the second phase of the project (H2020-WIDESPREAD-01-2016-2017-GA-739582) began with the aim of strengthening CPSBB's research potential. In December 2019, through additional support from the Operational Program "Science and Education for Smart Growth" (BG05M2OP001-1.003) began, the construction of modern scientific infrastructure, including an administrative and laboratory complex, two greenhouses and state-of-the-art research equipment. The campus is located on a 23-acre site in the city of Plovdiv. The Municipality of Plovdiv supports the Center by donating the land to implement research activities (Gechev et al., 2020). Beginning in January 2024, CPSBB's scientific endeavours have received financial support from the Executive Agency "Programme Education" through the direct allocation of grant BG16RFPR002-1.003, titled "Sustainable Development of Centers of Excellence and Centers of Competence." The funding extends over six years and is contingent upon achieving specific results, including scientific publications, intellectual property protection (such as patents and utility models), securing project or business funding, hiring new research and innovation staff, and completing public procurement processes for acquiring innovative equipment. This article offers an in-depth sustainability analysis, considering a range of management and financial indicators and external factors that influence the Center's growth and long-term viability. The study presented in this article emphasizes the vital importance of a consistent state policy and the development of a robust relationship between businesses, scientific organizations, and society.

Data and Methodology

Content analysis was the primary method utilised in this study, and CPSBB's annual financial reports (AFRs) for the past six years (2017-2023) were analysed. These reports were officially published on the website of the Commercial Register and the register of non-profit legal entities, and financial values are presented in euros for clarity.

The analysis encompasses the productivity of CPSBB, including scientific publications, filed patents, utility models, and successfully implemented projects. This permits the authors to evaluate the data

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quantitatively and qualitatively. The quantitative indicators assessed include the number of published articles, acquired funding, and the number of successful projects. The qualitative indicators are related to the Impact Factor (IF) of scientific publications and human resources. The research subject is CPSBB, which commenced its activities with the financial aid of the PlantaSYST project and evolved into a sustainable European Center of Excellence. The study investigates the management, internal, and external factors that have influenced the development and sustainability of CPSBB.

The research hypothesis suggests that similar scientific organisations are crucial in the modern scientific landscape of Bulgaria and Europe, and their sustainability can be secured through the efficient use of European and national financial instruments. To confirm this hypothesis, the following three tasks have been identified:

Task 1: Management analysis. This task involves examining the legal and administrative framework related to the establishment, growth, and sustainability of CPSBB and the governance bodies that oversee its operations.

Task 2: Internal factors investigation. This task thoroughly examines CPSBB's Annual Financial Reports (AFRs) between 2017 and 2023. The organisation's capacity to generate new knowledge and prepare a new generation of scholars will be evaluated based on an analysis of its publication activity and successful rate of project applications.

Task 3: External factors investigation. This task involves presenting CPSBB in the context of European and national policies for developing research activities.

Results and Discussion

Numerous researchers have devoted their efforts to studying sustainable development. Initially, sustainability was viewed as addressing environmental problems, but it has since come to encompass social, ethnic, and economic issues (Carroll, 1981). Sustainability has been broken down into a combination of internal and external factors. The external factors include a country's legal system and cultural, social, and economic characteristics. The internal factors, on the other hand, are the established systems of work within an organisation and the collaboration with stakeholders (Burke & Gaughran, 2007).

Law (2010) investigates the motivations and principles of sustainable development that guide high-tech companies and can serve as a model for sustainable development. The study examines the work of researchers, introduces a third determinant—the attitude of management as a factor in the integration of sustainable development—and proposes a research model. As Law (2010) identifies, the key motivating factors (MIE) that influence the adoption of sustainability development strategies include management (M)—strategy/policy and mindset; internal factors (I)—system, measures, need to advance, and performance enhancement; and external factors (E)—laws, regulations, social pressure, market trend, and competition.

Management

Like-minded individuals initiated the establishment of CPSBB to create an independent, democratic, politically non-aligned, voluntary organisation for carrying out activities for the public benefit. As a non-profit association, the Center operates according to the regulations governing non-profit legal entities, as outlined in the legislation of the Republic of Bulgaria and as specified in CPSBB's statute.

The primary objectives of the Center are to advance, promote, and support scientific activities in the field of plant systems biology and biotechnology in Bulgaria, as well as to promote and validate achievements in the field and improve the quality of fundamental and applied research by fostering the development of scientists and implementing of new technologies. The Center engages in various activities to achieve these goals, such as conducting fundamental and applied research and fostering collaboration with business and government organisations. Moreover, CPSBB is accredited to educate PhD students and award doctoral degrees. The Center regularly organises courses and workshops and participates in national and international scientific projects.

CPSBB aims to conduct economic activities related to services in metabolomics and bioinformatics, consultancy, and integration of innovations and analyses. Currently, CPSBB has a utility model titled "Nutrient medium for *IN VITRO* propagation of plants of the species *Haberlea rhodopensis* friv." Among the Center's activities are organising conferences, seminars, and workshops.

The CPSBB operates on the principles of equality and mutual respect among its members, regardless of their race, citizenship, religion, or political affiliation. Each member can vote, participate in the organisation's management, and receive information about its activities.

The funding of CPSBB is derived from various sources, including revenue from projects financed by national and international funding bodies, services provided to companies and universities, and membership fees. The General Assembly is the supreme body of the CPSBB and is responsible for making decisions that determine the centre's development strategy and policy. The Executive Board, on the other hand, is responsible for the operational management of the CPSBB and implements the decisions made by the General Assembly. The Executive Board submits the CPSBB's budget and activity report for approval by the General Assembly. The Chairman of the General Assembly also serves as the Chairman of the Executive Board. He is elected for five years, with the possibility of a consecutive term. The CPSBB has established an International Scientific Advisory Board (ISAB) to advise the institution on strategic and scientific goals and core activities. ISAB is an independent external body that provides objective assessments and recommendations for the future development of the Center. The management structure and developmental strategy of the CPSBB have provided a clear plan for establishing and developing the first centre of excellence in Bulgaria.

Internal factors

The advantages of the Center's status as an independent legal entity include swift and effective decision-making, a flexible approach to choosing personnel and partners, and the ability to support researchers in submitting project proposals. Despite these advantages, the primary drawback to the sustainability of the Center is the absence of regular state funding. Internal factors such as the established system of operation, the recognised need for development, and the motivation of the staff to preserve and increase the quality and integrity of scientific research are crucial. The perceived need for growth is vital to securing funding, which is the foundation of the Center's sustainability. Between 2017 and 2023, the CPSBB has generated over €21 million in revenue. Grant funding is essential for the founding, development, and continued operation of the Center. Revenues from project funding, including research, infrastructure, and mobility projects, account for more than 99% of the total income. Revenues from commercialising scientific products comprise less than 1%, reflecting one of the significant challenges faced by the scientific community in Bulgaria: the transfer of technologies and collaboration with businesses.

CPSBB does not receive any funding from the state budget. For comparison, data are presented for CPSBB and two Bulgarian scientific institutes receiving state funding under the governance of the Bulgarian Academy of Sciences—the Institute of Molecular Biology "Acad. Roumen Tsanev" (IMB) and the AgroBioInstitute (ABI), which is part of the Bulgarian Academy of Sciences. Figure 1 illustrates the income distribution from grants and services as a percentage of the organisation's budget.

The data demonstrate that CPSBB's funding between 2017 and 2020 was entirely grant-based. At ABI, the proportion of grant funding increased to 65% in 2020 from 40% in 2017. The institute also received budgetary funding throughout this period, which augmented the organisation's budget to 100%.

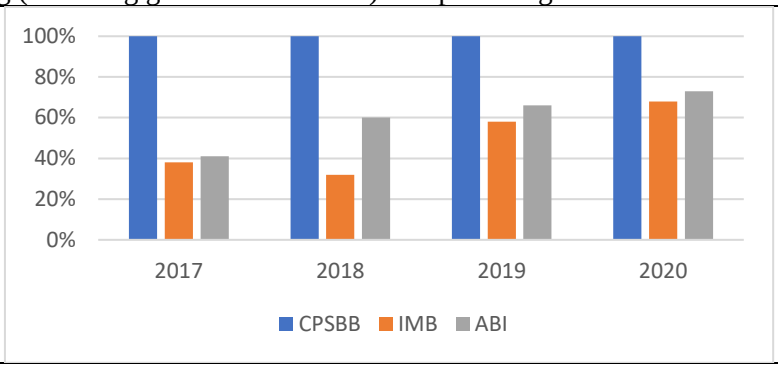
Similarly, the IMB experienced an increase in project funding from approximately 40% in 2017 to 62% of the institute's total funding in 2020. State funding also supplemented the institute's budget, covering the difference up to 100%.

The data is from the CPSBB's 2017-2020 Annual Reports, the IMB's 2020 Annual Report, and the ABI's Development and Management Program for 2021-2025.

The graph in Figure two depicts the projects implemented by the CPSBB and categorises the organisation's finances according to their origin. The funding is directly proportional to the number of successful projects, and the data demonstrates a steady increase in these numbers over time. In 2017, the Center started operating with the financial support of a single project, and by 2023, the total number of projects, contracts, and donations had increased to 39.

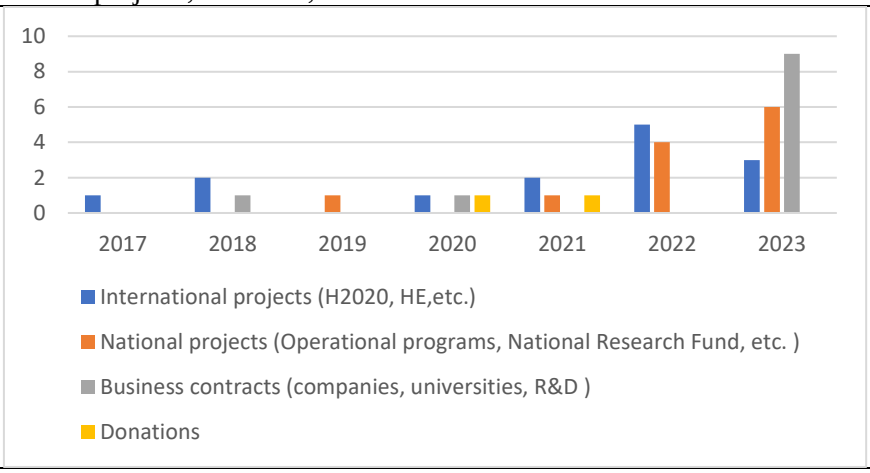
In recent years, the number of projects has risen considerably, from just one in 2017 to 39 projects in 2023. CPSBB is implementing 14 international projects, 12 national projects, and 11 service contracts with various companies, universities, and scientific organisations. While the number of business contracts is increasing, the financial support provided through these contracts remains limited. Between 2017 and 2023, the organisation received donations from individuals through funding or equipment.

Figure 1: Funding (including grants and services) as a percentage of the overall budget.



Source: Authors (2024)

Figure 2: Number of projects, contracts, and donations



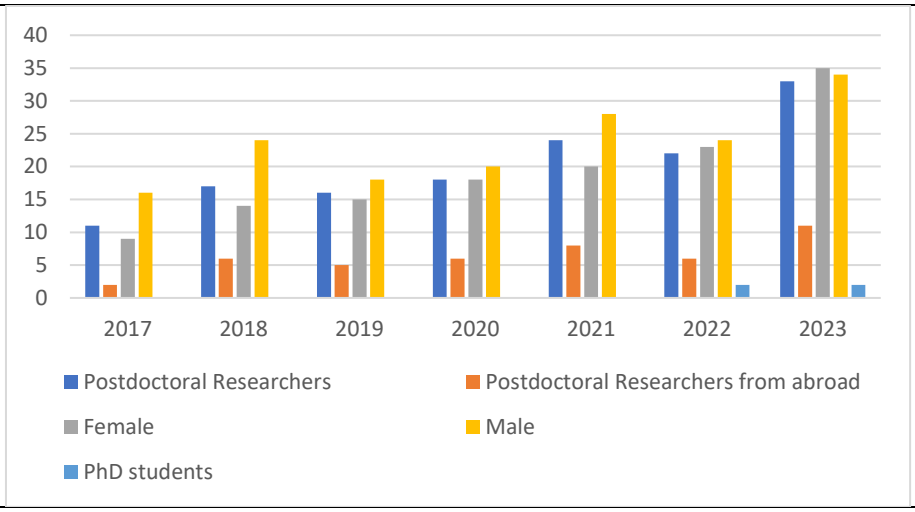
Source: Authors (2024)

Considering the significance of projects as the primary driving force behind the Center's sustainable development, the organisation's management is dedicated to attracting talented national and international researchers and providing cutting-edge equipment and research facilities.

Figure 3 presents data on permanent and temporary staff members of the CPSBB from 2017 to 2023, with a cumulative total of 298 individuals. These individuals comprise researchers, administrative staff, and technical staff. The average annual staff count is 42 professionals employed on full-time or part-time contracts. The need for specialised expertise to complete short-term tasks, as well as an increase in project activity, has necessitated the hiring of temporary staff under civil contracts. This is one of the reasons for the more than threefold increase in the number of employees at the Center in 2023 compared to 2017. Acquiring highly qualified research and administrative and technical personnel is essential for the growth and sustainability of any organisation, making it a crucial aspect to consider. CPSBB's accreditation by the National Evaluation and Accreditation Agency (NAOA) in 2021 was a significant achievement in this direction. The authorisation to train doctoral students in professional direction 5.11 Biotechnologies is valid until 30.07.2025. In 2022, two doctoral students were enrolled in individual doctoral programs. CPSBB's accreditation offers more opportunities to attract and retain high-quality researchers.

CPSBB's publication activity is focused on cutting-edge research. It utilises the latest genetics, functional genomics, metabolomics, and bioinformatics technologies to investigate complex gene regulatory networks and metabolic pathways governing plant development, stress physiology, and the production of valuable metabolites with potential market applications.

Figure 3: Personnel

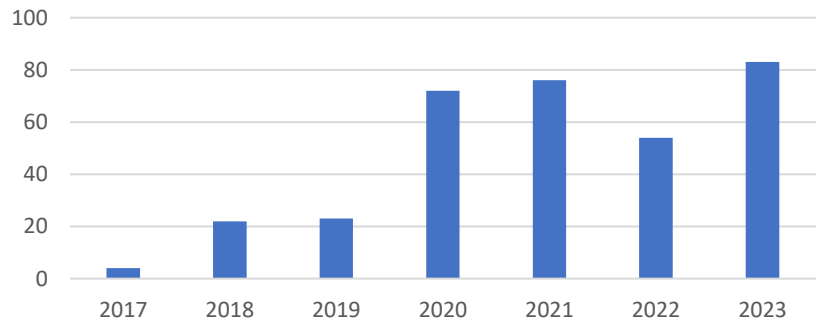


Source: Authors (2024)

As of 2024, the CPSBB has shown steady growth in publication activity, with over 300 high and medium IF publications published between 2016 and 2023. During the same period, the organisation secured financing by implementing more than 40 projects from international and national funding bodies (Gechev et al., 2024).

Some of the most recent studies published in March 2024 include Journal of Experimental Botany (IF 6.9) - ABA INSENSITIVE 2 promotes flowering by inhibiting OST1/ABI5-dependent FLOWERING LOCUS C transcription in Arabidopsis (Ali et al., 2024); Cellular and Molecular Life Sciences (accepted) (IF 8) - The genome of *Haberlea rhodopensis* provides insights into the mechanisms for tolerance to multiple extreme environments (Gupta et al., 2024); International Journal of Molecular Sciences. 25(4): 2441. (IF 5.6) Myconoside and calceolarioside E restrain UV-induced skin photoaging by activating NRF2-mediated defence mechanisms (Stoykova et al., 2024); International Journal of Molecular Sciences. 25(1): 352. (IF 5.6) - Icariin improves stress resistance and extends lifespan in *Caenorhabditis elegans* through hsf-1 and daf-2-driven hormesis (Todorova et al., 2024).

Figure 4: Number of Publications



Source: Authors (2024)

External Factors

National and European strategies, policies, and financial instruments that aim to establish Centers of Excellence and enhance research opportunities in Europe facilitate the establishment and growth of the CPSBB.

The strategic context at the European level

Horizon 2020 (H2020), the European Union's long-term research and innovation program, operated from 2014 to 2020 and allocated close to €80 billion from the EU budget. This common strategic framework for funding excellence in research and innovation attracted additional investments from the private and public sectors.

The European Research Area; Communication on Smart Specialization (COM (2017)376 final): Boosting the innovation and competitiveness potential of Bulgaria/Plovdiv region as a foundation for

sustainable growth and promoting interregional cooperation, a vital element in globalised economies. The program addressed the priorities of the Bulgarian Smart Specialization Strategy.

Renewed European Agenda for Research and Innovation (COM (2018) 306 final): It ensures essential public investment and stimulates private investment, particularly important for countries like Bulgaria, lagging in these indicators. The agenda supports the rapid dissemination of innovation and uptake throughout the Union and helps to reduce the innovation divide in Europe between the North and the South, as well as the West and the East.

A new industrial policy strategy (COM (2017) 479 final): It aims at upgrading the industry for the digital era, as exemplified by the CPSBB's AgroDigiRise project. This strategy builds upon Europe's leadership in promoting a low-carbon and circular economy. Several research projects undertaken by the CPSBB are aligned with this direction, such as BOOSTER, CropPrime, and NatGenCrop. Collaboration with Member States, regions, cities, and the private sector is vital to this strategy. This is one of CPSBB's strategic goals, which is being implemented through various projects, such as PlantaSYST.

Program for Acquiring New Skills: Detailed Action Plan for Sectoral Cooperation on Skills (COM (2016)381 final): This program addresses several points aimed at enhancing human capital, employability, and competitiveness, including a focus on digital skills, strengthening skills intelligence and cooperation in economic sectors, and expanding learning opportunities. At CPSBB, several national and European projects are also dedicated to promoting science among students, doctoral students, and the general public, such as KTRIO (Researchers in the Triangle of Knowledge), Infodemia: Science and Journalism United Against the Infodemic, and Motivation.

A renewed EU agenda for higher education (COM (2017) 247 final): A renewed EU agenda for higher education (COM (2017)247 final): The establishment of CPSBB’s research complex under the Operational Programme "Science and Education for Smart Growth" aligns to enhance the capacity and output of higher education institutions by funding innovative partnership projects between institutions and their partners, as well as investing in infrastructure, facilities, skills, and innovation projects through European Structural and Investment Funds (ESIF).

A European Green Deal (COM (2019) 640 final): The CPSBB is committed to the EU Green Deal to protect citizens from environment-related risks and impacts and help transform the Bulgarian economy and society to put it on a more sustainable path. Several national and EU projects implemented by the CPSBB now relate to protecting the environment and sustainable agriculture: AbioStressTolerance, BELIS, BOOSTER, CropPrime, NatGenCrop, and RESIST.

European Green Deal (COM (2019) 640 final) Some of its goals are a priority for CPSBB, as the organisation aims to foster sustainable development in Bulgaria via bio-based technologies. CPSBB has been actively realising national and EU projects to promote and develop sustainable agriculture supporting this objective. These projects include AbioStressTolerance, BELIS, BOOSTER, CropPrime, NatGenCrop, and RESIST.

In line with Shaping Europe's Digital Future (COM (2020) 67 final) and A Farm to Fork Strategy for a Fair, Healthy, and Environmentally Friendly Food System (COM (2020) 381 final), CPSBB demonstrates a commitment to promoting digitalisation and environmental sustainability. As part of the AgroDigiRise project, CPSBB aims to be part of Bulgarian agriculture’s digitalisation process while working towards a healthier and more environmentally friendly food system through initiatives such as the HealthyDietsForAfrica project. It focuses on introducing new crops with improved nutritional qualities, utilising environmentally friendly agricultural technologies to enhance crop yield, and developing fruits and vegetables with increased shelf life.

The strategic context at the national level

The National Development Programme BULGARIA 2030 (NDR BULGARIA 2030): By offering training for PhD students in Biotechnology, as well as a range of specialised courses, CPSBB aims to contribute to the lifelong learning initiative of the program. In addition, CPSBB is committed to conducting high-quality fundamental and applied research, as evidenced by its increased number of publications and citations and its successful collaborative research projects. The Centre is also actively involved in internationalisation and participates in the European Research Area through its international research projects and joint publications with international scientists and research entities. CPSBB is continuously developing its research infrastructure to support its research activities further. In addition,

the new Operational Programme (OP) will support the employment of proficient research personnel and the retention of existing personnel, helping to prevent brain drain from Bulgaria. The National Strategy for the Development of Scientific Research in the Republic of Bulgaria 2017-2030 outlines several goals for the nation's scientific research, which CPSBB is dedicated to achieving. To this end, the CPSBB is working towards achieving the following objectives: enhancing the development of human potential, improving infrastructure, achieving a balance between fundamental and applied research, promoting sustainable restoration of Bulgaria's international research positions, increasing the quality and quantity of research with regional and national significance, and stimulating applied research that aligns with the Innovation Strategy for Smart Specialization (ISSS).

Consistent with the Strategy for the Development of Higher Education in the Republic of Bulgaria 2021-2030, has been granted accreditation to confer Doctor of Philosophy (PhD) degrees in Biotechnology.

The National Roadmap for Research Infrastructure 2020-2027 (NRRI) identifies the CPSBB as a centre of strategic importance for Bulgaria. National Strategy for Small and Medium-sized Enterprises 2021-2027 (NSME): By engaging with and actively cooperating with Bulgarian SMEs (e.g., Bevine, Opora Zaden, Ondo), CPSBB is supporting NSME.

Digital Transformation of Bulgaria 2020-2030: As mentioned above, CPSBB is participating in the digital transformation of the Bulgarian agricultural sector through the AgroDigiRise project.

Conclusion

CPSBB operates in a highly competitive external environment with ever-evolving stakeholder needs. National and European legislation and policies support the establishment and early development of Centers of Excellence. However, these centres must be equipped to thrive in a competitive scientific and market landscape. The analysis highlights the importance of strengthening the "business-science" connection.

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