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Multi-Stakeholder Networks as Governance Structures and ICT Tools to Boost Blue Biotechnology in Spain

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Abstract: Blue Biotechnology (BBt) is a young and promising sector in the Mediterranean region with the potential to drive innovation and strengthen the Blue Economy (BE). However, its progress is constrained by fragmented coordination among stakeholders, impeding policy development and efficient resource management. Under this context, this study investigates the role of networks of diverse stakeholders, particularly the Spanish Blue Biotechnology Hub (BBHub) and a digital tool, ICT Matchmaking Tool (which connects network actors), in addressing these challenges by fostering collaboration, enhancing governance and supporting sustainable innovation. Building on this, the research employed the quadruple helix model (administrations, academia and research, industry and society), engaging 214 individuals from 130 organizations in the BBHub network. A survey assessed participants' involvement and influence perceptions, followed by the formation of a discussion group "called sherpa group" of 10 key stakeholders for in-depth discussions through semi-structured interviews and meetings. Through this approach, key barriers to BBt and potential solutions for BE sustainable growth in Spain were identified, including regulatory obstacles, limited funding or weak public-private collaboration. Among the solutions proposed were the simplification of administrative processes to create new business, the creation of specific funding opportunities or the implementation of labelling policies to promote BBt products and value chains. Considering these findings, the study demonstrates that the BBHub network and ICT Matchmaking Tool could enhance stakeholder coordination, governance and decision-making processes in Spain. By addressing these gaps, these tools enable collaboration and better coordination among actors, contributing to sustainable marine resource use and innovation in the BBt and BE sector. However, sustained progress requires stable funding and stronger stakeholder commitments. In turn, as a broader implication, this research provides a replicable model for leveraging open innovation and multi-stakeholder frameworks to promote coordination, policy development and sustainable growth in the BBt and BE sectors. Thus, it offers insights into addressing governance challenges in Spain and the Mediterranean, advancing the use of marine bioresources through collaborative approaches.

Keywords: networks of actors; governance structures; ICT solutions; mediterranean stakeholder collaboration; blue biotechnologies

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1. Introduction

The concept of the BE is rooted in the idea of mimicking natural processes to create more efficient and profitable production models [1]. In line with this idea, the BE refers to the sustainable use of ocean resources for economic growth, improved livelihoods and marine ecosystem health. It encompasses industries such as fisheries, aquaculture, maritime transport, renewable energy, coastal tourism or blue biotechnology [2]. Therefore, the BE concept integrates environmental sustainability with economic development. All, emphasizing innovation, clean technologies and the circular economy model, which focuses on reducing waste and maximising resource efficiency [3]. However, there are multiple definitions of the BE, reflecting diverse perspectives based on geographical, economic and environmental contexts that converge on issues of sustainability and innovation, but it can vary in their focus depending on regional priorities [4,5].

Globally, the BE has been driven by initiatives such as the 2012 Rio+20 Conference, which highlighted oceans' role in sustainable development. With the focus on balancing economic benefits while preserving marine biodiversity and addressing challenges like pollution, climate change and global ocean governance [6,7]. In parallel, under the umbrella of this context, several initiatives were launched. Such as, in Europe, the EU Blue Growth Strategy or in Spain the Blue Economy Plan 2021–2027 that focuses on fostering innovation in blue sectors while ensuring environmental protection [8,9]. In this line, these strategies prioritize sustainable aquaculture and fisheries, ocean energy, coastal tourism or blue biotechnology. Linking this with significant investments in research and innovation. For example, the Horizon Europe program or the RDI national plan in Spain. Both, aimed to enhance competitiveness and sustainability in marine industries and other key stakeholders [10–12].

However, various stakeholders have sought to define the BE in ways that prioritise specific ocean-related challenges, solutions and participants [13]. Central to this approach is the recognition that well-preserved ecosystems are more productive, forming the basis for sustainable development [14,15]. Moreover, despite all these efforts, there is still no single interpretation of the BE or how it can be effectively applied to achieve long-term sustainability [6,16].

In this line, several investigations argued that the BE may concentrate power and wealth among a few stakeholders while failing to acknowledge the rights of local communities which are directly connected to the sea [17–20]. Consequently, there is an ongoing debate about ensuring that BE initiatives are equitable, fair and sustainable across different jurisdictions and for various ocean users [20–22].

To address these concerns, the BE concept has been refined to emphasise equitable access, social benefits, climate regulation and conservation. In general, highlighting aspects like carbon storage, coastal protection, cultural values or biodiversity [4,13,16,23,24]. Nonetheless, a key challenge in ocean governance remains reconciling the aspirations of BE with the social and cultural values of local communities [25,26].

Under this situation, BBt it is a young sector and could play a significant role in this context as a relatively new field where various sectors of the BE converge. BBt enables local communities to participate and co-create governance and innovation processes. Also, fostering the integration of local knowledge, interests and perspectives, which enhances trust, social learning [27,28] and coordination within the BBt sector. Therefore, BBt holds substantial potential to drive innovation by advancing science and technology for the sustainable exploitation and production of aquatic organisms and by providing valuable knowledge, goods and services [29]. It contributes across different BE sectors. From aquaculture, cosmetics or pharmaceuticals to biofuels derived from marine algae and the digitization of related processes, making it a key player in Europe's BE [30]. In this sense,

the sector has seen exponential growth in recent years, significantly contributing to the EU's BE [31,32]. (See Figure 1).

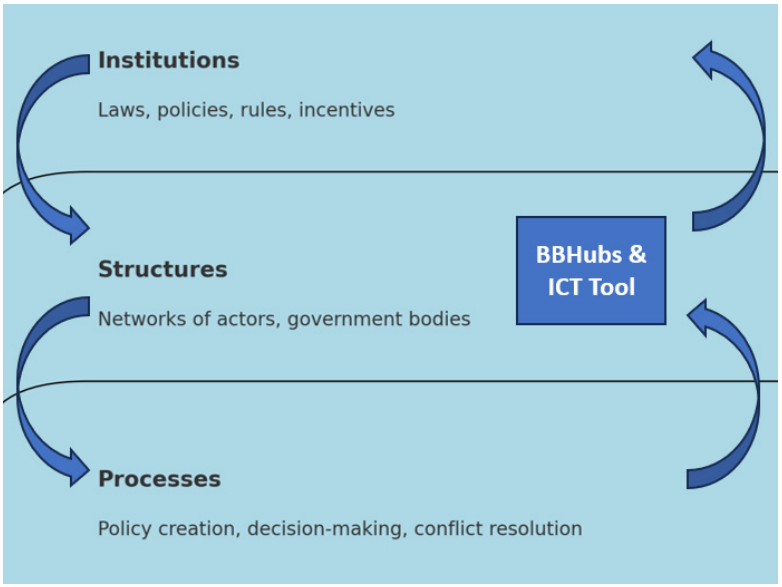

Figure 1. Scheme showing the main elements to improving the coordination and the governance of BBt and BE in Spain and the potential role of BBHub and the ICT Tool.

Moreover, BBt, combined with advancements in innovative technologies and digitisation, could offer substantial opportunities for economic growth, sustainable transitions and job creation across Europe and beyond [33,34]. Thus, BBt provides applications spanning technology development, industry and environmental management, always aimed at benefiting society [35]. However, in Spain and the Mediterranean, BBt actors are often dispersed and poorly coordinated, mainly because it is a relatively young sector [36].

Against this background, the creation of interdisciplinary, collaborative local networks could promote communication and coordination channels among key stakeholders [37]. Including policymakers, governments, industry, technology centres, scientific institutions, universities or civil society. This can improve governance processes within the BBt sector [38]. Such networks function as governance structures [39]. Also, fostering cooperation among research, industry and policy sectors to transform scientific and technological advances into equitable, successful industrial, economic and commercial initiatives while preserving natural resources [40].

In turn, recent studies highlight that establishing collaborative networks is crucial for advancing and improving the BBt sector [38] and nature [41] or marine conservation efforts [42]. These networks can drive productive, creative and innovative outcomes to address pressing social, economic and environmental challenges. Networks enable the exchange of ideas, resources, equity and trust, thus improving coordination among actors [43,44]. In this line, several collaborative networks have already been established within the BE and BBt. Including scientific conferences, trade fairs and sector-promoting events [38].

However, it is crucial to be focused on more formal and stable networks. With a long-term vision, to promote sustainable actions and development models while enhancing policymaking in the BBt and BE sectors [45,46]. To this end, the present research focused on the stakeholder network created in Spain, the BBHub, and, in parallel, in seven other Mediterranean countries (France, Italy, Slovenia, Croatia, Greece, Montenegro and Portugal). The BBHub network was financed by EU, and its objective is to create a collaborative

BBt multistakeholder network formed by diverse actors from academia and research, administration and industry to society, with different visions and interest in Spain and the Mediterranean. Its aims is to improve stakeholders' coordination, their governance and to promote sustainable use of marine resources through biotechnological solutions.

From this perspective, the research aims to evaluate the effectiveness and role of the BBHub network (as a multistakeholder network) and the ICT tools in improving the governance of BBt and its situation in Spain. Therefore, investigations focus on the work conducted in Spain in the framework of the Spanish BBHub. This includes investigation from the identification of key actors and BBt best practices, to the perception analysis and the implementation of discussion group sessions to (1) identify the main barriers and challenges of BBt and (2) discover potential and agreed solutions to address these challenges and by whom. This work also led to the collaborative development of the "ICT Matchmaking Tool". Designed to connect actors and facilitate cooperation. This tool aims to enhance the use, management and conservation of marine resources in an increasingly digitized society [47]. Therefore, by combining social and technological aspects, the BBHub network in Spain, could provide diverse knowledge sources, solutions (technological, social and environmental) and processes (conflict resolution or policy development). All this will strengthen BBt governance and increase its resilience to socio-economic and political changes [38,48,49].

Thus, this research highlights the findings obtained from diverse stakeholders, 214 participants from 130 organisations, involved in the network. In this sense, the investigation allowed us to identify key challenges facing the BBt sector, such as regulatory issues, limited public-private collaboration, financing difficulties or a lack of public awareness regarding new BBt products and services. Moreover, it helped identify core actors to lead changes and cope with it and to promote the ICT Matchmaking Tool in Spain and in the Mediterranean (Figure 2). In general, these findings could drive policy improvements. For example, by promoting collaborative governance or new participatory business models to boost the BE and BBt sectors, it may serve as a blueprint for adopting better coordination and open innovation in Spain and other regions. However, as mentioned, while BBt has many potentials to drive BE, it still has numerous barriers to growth and other issues to be resolved that deserve attention (e.g., regulatory complexities, limited funding or technological constraints). In this sense, the effective implementation of the proposed solutions would require time, resources and continued commitment from stakeholders [50].

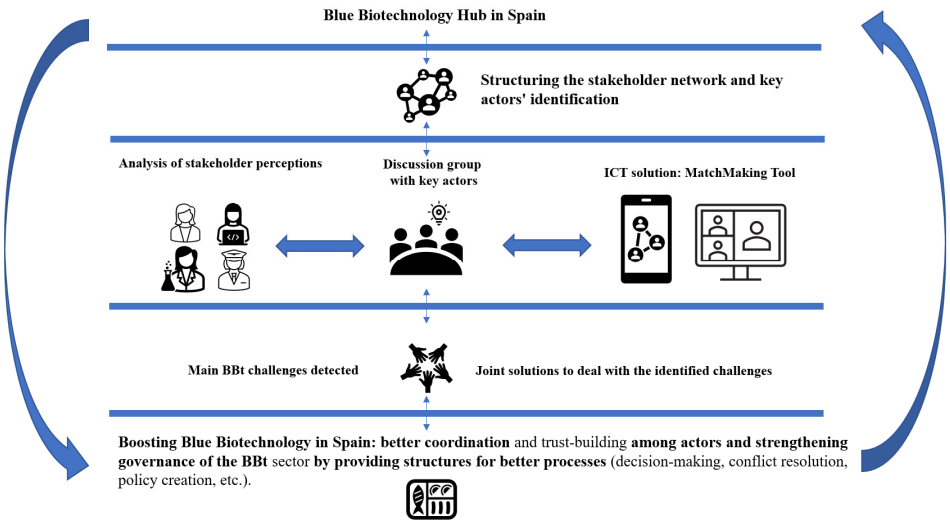

Figure 2. Overview of the research showing the connection between the different phases of the work carried out and the results obtained in the BBHub network in Spain.

Nonetheless, the findings of the present research could provide an initial scenario for further progress, especially in key aspects to improve the coordination of BBt and BE actors and also to foster its growth while facilitating more equitable access to information, resources or promoting socio-economic and environmental sustainability in Spain. Furthermore, it could serve as a reference elsewhere in the Mediterranean.

2. Methods and Materials

This section outlines the methodology, tools and workflow used in the research (Figure 3). In this context, the study employed a structured methodology that seamlessly integrated qualitative approaches to produce robust and interpretable outcomes. The process began with a comprehensive mapping of best practices across Spain, which identified key stakeholders from both the public and private sectors. This groundwork was followed by targeted surveys to uncover significant challenges and related issues (Section 2.1). Building on these findings, a "sherpa group" of 10 stakeholders was formed to participate in discussions and semi-structured interviews, fostering refined insights and collaborative solutions (Section 2.2). Complementing these efforts, a digital matchmaking tool was co-developed to facilitate networking and information exchange among stakeholders (Section 2.3). To ensure both transparency and accessibility, the findings were communicated using simple metrics such as mean scores and response rates, while iterative feedback loops were employed to validate and enhance the methodology.

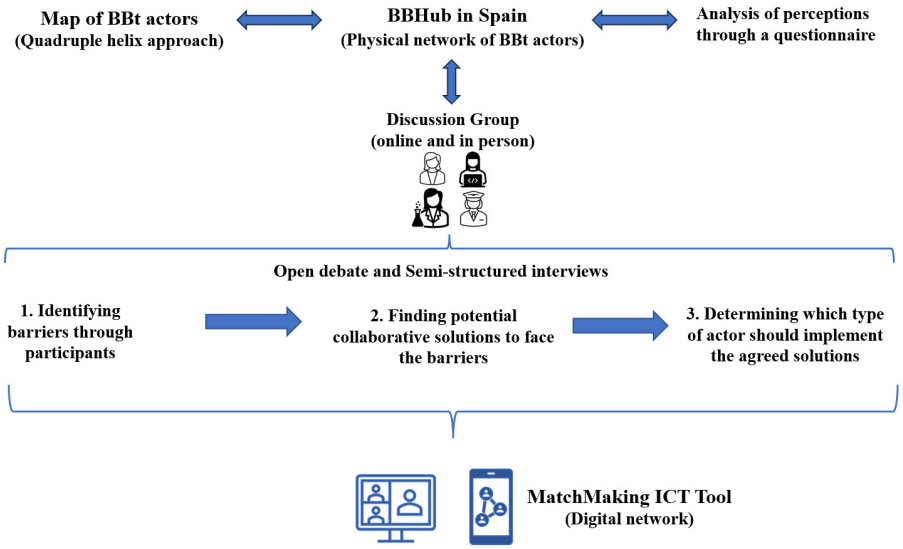

Figure 3. Overview of the methodology, tools and workflow used in the research.

2.1. Identification of BBt-Related Stakeholders and Good Practices

The authors conducted an extensive stakeholder mapping to identify and select organisations and best practices relevant to BBt in Spain. The selection criteria were based on (i) a multistakeholder approach (quadruple helix model), involving and integrating public administrations, industry, research institutions and universities and society, considering their interest and influence and covering all coastal geographical areas of Spain (actors from the Atlantic and Mediterranean part); (ii) demonstrated best practices and experience in BE or BBt-related areas. Best practices were mapped, defined and selected according to the following criteria: (1) creation and development of successful companies; (2) successful technology transfer initiatives; (3) inspiring experiences related to technology support to other actors; (4) funding mechanisms that help innovation; (5) efficient and effective practices and methods related to innovation policy; (6) inspiring public-private

collaboration/networks; (7) marketing/brands developed that can serve as a reference or (8) projects of interest on BBt, BE and innovation in Spain; and (iii) organisations who have a leading role in innovation initiatives within the BE or BBt sector. This approach enabled the identification of several best practices in Spain, engaging policymakers, funding bodies and other public and private organizations critical to the sector's growth and development.

Thus, stakeholders were classified into four main groups administration, science and academia, industry and society (including NGOs, media representatives, clusters and innovation or technology centres), reflecting challenges faced by Mediterranean societies, such as bioeconomy, environmental protection, health and welfare, marine research, food security or climate change [51]. Building on this, the stakeholder mapping and best practices identification were treated as dynamic processes. In this line, a total of 214 actors from 130 organisations (38% scientific and academic, 16% industry, 9% administrations and 37% society) and 23 best practices were identified in Spain (Supplementary Materials). Thus, stakeholders were positioned on the map based on their interest and influence levels [52].

In this sense, the following work was conducted. First, identified potential actors were invited by mail to participate in the BBHub. Afterwards an online meeting was held if needed. Secondly, actors were integrated into the network and invited to complete an online survey sent by mail to assess their perceptions on its potential interest and influence in the BBt and BE, the main barriers and other issues in Spain. The survey consisted of 10 questions (Supplementary Materials). Therefore, Questions (Q) 1, 2 and 7 were related to the participants' perception of the interest, influence and importance of the BBHub. In parallel, Q9 and Q 10 were related to the usability of the ICT tool. All these five questions were analysed using a Likert scale (From very low: 1 to very high: 5). Another five (Q3, Q4, Q5, Q6 and Q8) were analysed through open-ended questions. In this sense, all information was collected, recorded and further analysed and correlated (Section 3.1). This survey also helped to pinpoint key individuals (based on their interest and influence) who formed a smaller a discussion group "called sherpa group" to further address all these questions and specific issues raised in the survey through open discussions (Section 2.2).

In parallel, to identify best practices, desk research was combined with the authors' expertise to gather and organize existing knowledge, which aided in locating local actors and innovators. Therefore, data on individual practices were then collected, covering the responsible organization, funding source, project description or relevant sector (e.g., aquaculture, cosmetics, health/pharmaceuticals, nutraceuticals, feed industry, energy, industrial processes, environment or other). Each best practice was categorized by type and selected following the criteria described above (e.g., business start-up, technology transfer, technology support, financing mechanism, policy management, collaboration/networking and marketing/branding). At the same time, technology and business readiness levels were also highlighted.

2.2. Discussion Group to Address Key Barriers and Potential Solutions

A discussion group of 10 key actors, referred to as the "sherpa group", was formed. For confidentiality reasons, specific details about the members and their organisations are not provided. This group included individuals with diverse views, interests and backgrounds (including four representatives from research and academia, three from industry, two from public administration and one from society) in the BBt and BE sector. Its main goal was gathering qualitative insights into barriers to BBt identified from the initial survey. In this line, four open sessions (one in-person and three online) were held from April to December 2021. The sessions were around two hours each, complemented by questions stated in the survey. These sessions were recorded, and the information was further analysed.

The discussion group, as noted by Eguruze [53], aimed to foster innovative approaches to societal challenges through openness to change and were conducted as a Living Lab [54,55]. This technique provided an innovative research and co-creation tool where the participants of the group were able to better identify solutions and address the challenges related to BBt in Spain [55]. Therefore, the sessions focused on getting consensus and verifying the main results obtained of the survey related to barriers, identifying promising BBt-related value chains and developing collaborative solutions and recommendations [56,57] to boost BBt and BE in Spain. Additionally, these discussions informed the iterative development of a matchmaking tool by clarifying social needs among Mediterranean region actors [58]. Thus, the stakeholders' concerns and ideas for fostering sustainable BE and BBt activities [59,60] were taken, analysed and promoted to better address BBt sector needs in Spain [30,61].

In the focus group sessions and survey, participants were informed that their data would be used anonymously and solely for scientific purposes, in compliance with EU data protection laws. They confirmed their consent by ticking a box on the questionnaire and were advised that an ethics committee would be established if needed.

2.3. Iterative Development of the ICT Matchmaking Tool

The ICT Matchmaking Tool prototype was developed by a multidisciplinary team to connect BBt actors. Initial meetings defined the tool's desired functionalities to facilitate network connections. A pilot version, hosted on the Marina platform (https://www.marina-platform.eu/login, accessed on 12 December 2021), served as a proof of concept (PoC) and was tested by the authors. Afterwards, this PoC was subsequently demonstrated in the four discussion group sessions, where participants provided feedback on its usability and functions, enabling iterative improvements to better meet BBt and BE actors' needs [62] in Spain. The tool's goal was to create a digital networking space that fosters information exchange and joint initiatives supporting sustainability and innovation in the BBt and BE sector.

Through this work, key aspects emphasised throughout the development process included collaboration between diverse stakeholders and sharing specific knowledge to support best practices, good governance and a shared vision [56,61,63–65]. Building on this, the participatory tool development process strengthened actor collaboration by emphasising mutual interests. This is a supportive environment for problem-solving, joint solutions and interpersonal relationships fostering trust [64]. In this sense, this approach is essential for advancing good governance and coordination [66,67] and promoting the sustainable use of marine bioresources [56].

3. Results

3.1. Interest and Influence of BBHub Network Actors in Spain

The initial survey revealed that 51.4% of stakeholders were satisfied with their participation in the BBHub network, recognising its significant role in advancing BBt in Spain. While 94.5% expressed interest and perceived influence to positively impact the sector locally, with potential for broader influence, only 16.6% showed strong interest and capacity for sustained involvement. However, 91.2% were willing to stay informed and collaborate occasionally. Despite general satisfaction, 78.8% highlighted the need for greater commitment from public administrations and decision-makers to strengthen BBt-related regulations.

The results also showed that academic and scientific actors are most interested in ongoing network participation but feel limited in their ability to influence policy or resolve conflicts. Meanwhile, actors from public administration and industry have higher potential

influence for regulatory improvements, though their active interest is constrained by limited time or resources. At the same time, the results obtained in the statistical analysis of the information show that the different actors (academia and science, industry, administration and society) have a similar average (high) in the questions Q1 (interest), Q2 (influence) and Q7 (willingness to participate and in the BBHub). However, public administration rates the network's importance much lower (Q7 score of 2.1) compared to their influence or interest levels. Society consistently rates all metrics as high or very high, indicating strong perceived importance and interest despite the low perceived influence. In this line, in the correlation analysis, it was observed that science and academia actors show consistent interest in participation in the network. Also, perceived influence in the BBt sector, and importance of the network to promote changes, suggesting alignment between their motivation and perception. In parallel, industry has high perceived influence (Q2) but only medium interest to participate in an active way (Q1) but high importance of the network perception (Q7). This reflects a gap between their influence and engagement in the network. In turn, public administration has high influence (Q2) but low importance perception (Q7). This suggests a potential lack of awareness of BBHub's importance. Finally, and in contrast, as observed, society rates all metrics as high, except for influence (Q2), showing enthusiasm to participate in the network but limited perceived influence and impact (Table 1).

Table 1. Main average results obtained through the analysis of perceptions related to the interest (Q1), influence of the actors (Q2) and importance of the BBHub in Spain (Q7).

Q1 (Interest of particpation in BBHub). From Vey Low: o to Very High: 5	Q2 (Perceived Influence in BBt Sector)	Q7 (Perception of Importance of BBHub Network)
Science and Academia: Very high (4.8) Industry: Medium (3.2) Public Administration: High (4.2) Society: High (4.1)	Science and Academia: High (4.1) Industry: Very high (4.7) Public Administration: Very high (4.7) Society: Low (1.9)	Science and Academia: Very high (4.8) Industry: High (4.1) Public Administration: Low (2.1) Society: Very high (4.7)
Mean score: 4.075	Mean score: 3.85	Mean score: 3.925

3.2. Main BBt Barriers and Proposed Collaborative Solutions in Spain

The survey and afterwards, the discussion group identified and reached consensus on primary BBt barriers and proposed collaborative solutions (Q4 and Q5). Also, key BBt value chains—algae production for high-value compounds, fishery and aquaculture discard valorisation, cosmetics, integrated multitrophic aquaculture (IMTA) and digitalisation—were highlighted. In this sense, major barriers include (1) regulatory and administrative hurdles that delay project implementation, (2) insufficient public–private collaboration and funding and (3) limited public awareness of BBt-generated products in Spain.

Moreover, participants proposed potential and targeted solutions, assigning implementation roles across stakeholder groups. Along this line, according to the findings in Q6, public administrations should lead regulatory improvements and create financing channels for new BBt ventures in promising areas like algae cultivation, digitalisation and discard valorisation. At the same time, universities and research centres, through multidisciplinary teams, should lead training for public administrators and support regulatory improvements based on applied research. Moreover, they should collaborate with industry to refine research processes in the identified value chains and to develop scalable business models. In turn, industry, for example, should enhance product marketing and labelling to improve competitiveness, especially against imports from outside the Spain and EU. Finally, society should spearhead initiatives to raise awareness about BBt products' benefits and sustain-

able BE and marine resource use in Spain and the EU. Through these coordinated efforts, the BBHub network could advance good governance steps and practices to overcome the sector's main barriers identified and drive BBt forward in Spain (Table 2).

Table 2. Main barriers, potential solutions related to promising value chains and who should implement them, identified in the research, to improve BBt governance and boost BE in Spain.

Main Barriers Identified	Potential Solutions to Address Barriers	Lead stakeholder Category	Relevant BBt Value Chains
Regulation, norms and standards	Improvement of administrative processes, creation of one-stop shops	Administrations	Algae, IMTA, Discards valorisation
	Standardisation and regulation of labelling for EU products	Administrations	Algae, IMTA, Cosmetics
	Advice and training for public administration staff	Research and academia	Algae, IMTA, Discards valorisation
Lack of public-private collaboration and funding	Specific calls for start-ups related to BBt	Administrations	Algae, IMTA, Cosmetics
	Enhancement of research productions processes in value chains and business models	Research and academia, Industry	Algae, IMTA, Discards valorisation, Cosmetics
Communication and marketing	Awareness campaigns on benefits of BBt products (environmental, nutritional, etc.)	Administrations	Algae, IMTA, Cosmetics
	Improved labelling on EU products	Industry	Algae, IMTA, Cosmetics
	Collaboration with influencers and social media groups	Society	Algae, IMTA, Cosmetics, Discards valorisation
	Promote use of the Matchmaking Tool to highlight benefits and products	Society, Industry	Algae, IMTA, Cosmetics, Discards valorisation

3.3. ICT Matchmaking Tool as a Digital Network for BBt Actors in Spain

Through the facilities included in Matchmaking ICT Tool interested SMEs, the research community, social actors, investors, etc. could connect and find information on professional events, experts, online material or best practice examples in one place. In this line, actors can meet directly with each other through videoconferencing or chat. This is an important step to move forward to disseminating different knowledge and expertise, all key aspects to be considered to boost and develop a sustainable BE and BBt in Spain and other Mediterranean countries [63]. Moreover, in this line, 73.4% of the participants emphasised that the ICT Tool is easy to use, the functionalities are well presented and most would utilise it (Q9). Nevertheless, also, in Q10, 70% highlighted that, in their daily tasks, it would be important to have technical support to encourage its full potential use (Table 3). It is consistent with the perception found in the feedback from participants in the discussion group sessions that the network (digital and physical) would play a very important role in improving the coordination of actors and boosting the BBt sector. However, at the same time, further work would be needed to promote them and with a long-term vision.

Table 3. Overall results obtained from research participants' responses on their perceptions related to the usability of the ICT Matchmaking Tool.

Question	Key Aspect	Agreement	Likert
Q9	Ease of use of Matchmaking Tool	73.4%	3.7
Q10	Need for technical support	70%	3.5

4. Discussion

Stakeholder networks could be essential governance structures for enhancing coordination and optimising natural resource management, including marine bioresources [39] in BBt or BE. Governance here involves laws, institutions, formal and informal rules, incentives and structures (such as government or network organisations) that shape stakeholder behaviours in resource use [39]. Therefore, networks, as noted in the literature, could play a key role in institutional strengthening [68] and the coordinated advancement of research [63], innovation [65,69,70] and sustainable marine resource use [71,72], All of this by promoting sustainable blue growth and establishing long-term agendas in BBt [36,73].

However, few networks integrate both social and digital dimensions in BBt or Be governance, particularly in Spain, where a paradigm shift may be needed to align governance with contemporary digital advancements [54]. In this line, research supports the potential of digital tools to enhance sustainable BE governance, offering data services that enable participatory decision-making or facilitate policy engagement [26,74,75] and, also, to promote sustainable resource management [38,54]. In this sense, for a resilient BE and BBt sector, establishing robust scientific and technological networks could be critical to enforce policies and improve value chains across Europe [30,31]. Nonetheless, challenges remain, particularly regarding connectivity in isolated areas [76] or securing funding to support social and digital tools in BBt and BE initiatives [50,69].

Under this situation, aligned with these objectives, the BBHub network in Spain and the ICT Matchmaking Tool could offer a singular governance structure, creating both physical and digital spaces for stakeholder interactions. These platforms could address key challenges in the Spanish and Mediterranean's BBt sector by incorporating stakeholder insights into development and encouraging collaboration. In this sense, this foundation could enhance stakeholder commitment to implementing sustainable solutions and providing a promising framework for advancing BBt and the BE sustainably across Spain and other Mediterranean regions. However, based on the results of our research, important efforts still need to be made, for example, to optimise the role of stakeholders in the BBHub and promote the use of ICT among actors in Spain. In this line, it would be important for the administrations to break the gap between their high influence and their low perception of the importance of the BBHub, perhaps through capacity building initiatives. At the same time, industry should look for ways to translate its high influence into greater interest through economic incentives or practical workshops. In parallel, science and academia actors must take advantage of their alignment of interest, influence and importance by boosting their role in knowledge and technology transfer, and no less important, society should increase its perceived influence (maybe, through participatory initiatives, to increase its role in success through awareness or consumption of new products or services), considering BBt products of Spain and Europe as opposed to others from abroad.

5. Conclusions

The BBHub network in Spain and the Matchmaking Tool could be important tools and serve as the structure of governance to reinforce institutions and its coordination and also to conduct efficient processes and to strength the relationship or collaboration among

multi-stakeholders [28] from industry, universities and research centres to administrations related to BE and BBt sectors and emerging value chains. Through them, networking may be promoted. Therefore, the participation of actors could be encouraged, and positive relationships between different actors could be improved. These can be key aspects for the development of good governance processes and digitalisation [77] in the BBt and BE in Spain while improving stakeholder coordination. All these points were stated throughout the research conducted. In this line, the processes allowed us the integration of different sources of knowledge to detect the main challenges and barriers that hamper the development of BBt and BE in Spain and also to find out how to tackle them in a collaborative way. In addition, they enabled to identify the type of actor (universities, administrations, industry or society) that should promote collective action to address the barriers and implement the potential solutions detected.

However, it was observed that efforts should be made to promote ways to increase the commitment and involvement of key actors in the BBHub network in Spain in the long term, especially industry and public administration. Furthermore, administrations should promote stable and lasting funding programs to support the BBHub network or to encourage the creation of new business models that stabilise and boost the BBt and BE sectors. In this line, it would be important to develop new channels of communication and interaction among actors to address relevant issues related to dissemination and promotion of new products generated from BBt. Here, the use of the ICT Matchmaking Tool could play an important role.

Moreover, more participation from stakeholders in this respect is needed, and this is not a trivial aspect, as participation is in trend in European organisations (or institutions) and is an important aspect of effective and lasting change governance processes. Nevertheless, it should be noted that it is not easy to achieve active and effective participation of key actors. This requires time to build trust, the willingness of each actor to participate and the interest of each organisation [27]. In this sense, as observed, the BBHub network in Spain and the ICT Matchmaking Tool could provide a physical and digital governance structure by facilitating the participation and trust creation process among diverse actors and, furthermore, to provide stakeholders with an easy access platform to build relationships or enable fairer and more equitable processes through the inclusion of diverse BBt and BE players, and this could be an important step towards facilitating a process of good governance and coordination of the BBt sector and BE in Spain.

Nonetheless, there is still a long way ahead to improve BBt, its norms or regulations. From a local to a national context and in terms of resources or political willingness to implement decisions and the identified solutions in an effective way, for example, to improve regulatory frameworks, increase economic incentives or through the creation of single windows in administrations. This could facilitate the creation of new businesses, where administrations should lead lines of action.

In turn, it has been observed that many organisations are interested in being part of the BBHub network in Spain. However, due to their daily tasks, they perceive that they cannot spend much time on this type of networking, even though they know that it can benefit them. In this sense, it is therefore necessary to continue to encourage and work closely with the key actors identified to effectively get them involved and implement the solutions agreed on.

Therefore, significant efforts remain necessary to enhance the governance and coordination of the BBt and BE sectors in Spain, particularly by optimising the roles of BBHub stakeholders and leveraging the use of the ICT Matchmaking Tool. In this sense, public administrations should give more active interest in the BBHub, for example, by implementing capacity-building initiatives; updating regulations or fostering value chains like algae,

cosmetics or the valorisation of fishing by-products. The industry could promote practical initiatives to show the quality of Spanish and EU BBt products. In parallel, science and academia should focus on knowledge transfer, fostering startups and advancing innovations and technology in areas such as algae farming or IMTA. Finally, society's role can be strengthened through participatory initiatives, awareness campaigns or collaborations with influencers. This way, the adoption and consumption of locally produced BBt products could be improved.

Finally, and important to be considered, we highlight that these results show the work conducted in Spain. However, in each territory, there will be a different political or socio-economic context [78]. This situation will determine how the participation of actors, their connection and exchange of information and knowledge process will be conducted [79] in the development of BBt and Blue Economy [48]. Regardless, with this research, we intend to help key stakeholders, public administrations, universities and research centres, industry and society to promote good governance processes and better coordination practices while fostering environmental, social and economic sustainability strategies adapted to each territory. In this sense, we hope that the BBHub network in Spain and the ICT Tool presented could become effective instruments to boost a sustainable BBt sector and BE in Spain and serve as a reference to be replicated and used in other parts around the world.

6. Limitations and Further Research Avenues

The results and conclusions obtained in the research were an important step forward. These findings will be useful to guide the way for future work and to address the limitations identified in the research. In this way, the full potential offered by the BBHub in Spain and the ICT Matchmaking Tool to boost BBT and BE in Spain could be realised whilst improving the coordination between stakeholders and the governance of the sector.

In this sense, it should be important to explore solutions and future research on how to address the following limitations found in the investigation: Time and resource constraints: Many stakeholders expressed interest in participating in the BBHub network but cited a lack of time and resources due to daily tasks. This limit sustained engagement and the effective implementation of proposed solutions.

Regulatory and political barriers: The development of the BBt and BE sectors in Spain faces regulatory hurdles and insufficient political commitment. The complexity of updating norms and creating supportive policies hinders progress and new BBt business creation.

Participation challenges: Achieving active and effective participation from diverse stakeholders is difficult. Trust-building, willingness and consistent engagement require a significant amount of time and effort.

Context-specific findings: The results are based on the Spanish context and may not fully apply to other regions. Socio-economic and political factors unique to each territory can affect stakeholder involvement and governance processes.

Limited awareness and support: Public administrations show limited interest in the BBHub network, which may slow down efforts to foster collaboration and innovation.

Consequently, and building on this, future research should be framed around the study of several specific issues and aspects considering these constraints.

7. Actionable Recommendations

The investigation, at the same time, provided important information for its implication for practice. This would reinforce the practical relevance of the results obtained and allow the definition of a real action plan to improve the situation of BBt and BE in Spain.

In this sense, as practical recommendations, future actions should explore innovative ways to foster the long-term commitment and involvement of key actors, especially industry

and public administrations. Therefore, the development of governance strategies with a bottom-up and collaborative vision could be a first step. Such strategies would promote environmental, social and economic sustainability in the biotechnology sectors, including the promotion of new businesses and innovations.

Building on this, key actors should focus on the identification and analysis of effective regulatory frameworks and policy strategies that can serve as a reference and drive the development of the BBt and BE sectors. Moreover, examining successful models from other regions could provide ideas.

In parallel, it would be valuable to promote actions for digital support to enhance the impact and use of ICT Tools among key actors for information exchange or in connecting actors. This kind of action can promote cross-regional and cross-country collaborations in emerging value chains such as IMTA, algae farming or cosmetics production.

All of this should be combined with public awareness and participation actions to improve social engagement through participatory initiatives, awareness campaigns and collaborations with influencers that could strengthen public support for BBt products.

Therefore, addressing these recommendations would help to boost the socioecological and socioeconomic sustainable growth of the BBt and BE sectors in Spain and other countries.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su17010155/s1, File S1. Questionnaire addressed in the survey and open debate.

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