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Open innovation initiatives in a public research institute: proposing paths from the organizational learning

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1 INTRODUCTION

The Brazilian Agricultural Research Corporation (Embrapa) is a public research institute created in 1973. Throughout its history, together with partners, it has invested efforts to contribute to the development of Brazilian agriculture and has become a world reference in the generation of technologies for tropical agriculture (Franco, 2001; Alves et al., 2012; Vieira Filho, 2022).

In order to keep up with changes in the macro-environment, making use of the possibilities generated by the Legal Framework for Science, Technology and Innovation (Law No. 13,243/2016), Embrapa has improved its processes and value-generating structures. In this sense, in 2018 has been published Embrapa's Innovation Policy, which institutionalized the creation of new approaches connected to open innovation, which refers to the co-creation and co-development of technologies based on the transfer and obtaining of knowledge and ideas in interaction with other actors (Chesbrough, 2003).

Although Embrapa has been developing technologies in partnership with other institutions since the 1970s, its Innovation Policy is fairly recent. As such, its internalization is in a consolidation phase, considering the diversity of Embrapa's 43 Decentralized Units (DUs) in terms of the stages of organizational learning, with some DUs in the acquisition phase, others in the sharing phase and others already using and practicing this knowledge (Nevis et al, 1995), in other words, carrying out open innovation initiatives.

In view of this, the general objective of this article is to analyze innovation initiatives promoted by Embrapa by means of a multiple case study and to propose ways of directing new initiatives of this nature. The specific objectives are: 1. to identify strengths, weaknesses and opportunities for improvement through the analysis of innovation initiatives carried out by the Decentralized Units, 2. to identify possible similarities and complementarities through comparative analysis, and 3. to propose paths and contributions that can be used in new initiatives of this nature.

To facilitate understanding of the context under investigation, the concepts of the silo effect are used, which refers to the difficulty regarding the interaction between one or more parts with the rest of an organization (Tett, 2015), open innovation, and contributions related to network theory. To make the work feasible, an analysis model was established that includes an adaptation of the Business Model Canvas (Osterwalder and Pigneur, 2010), SWOT analysis and semi-structured interviews with employees responsible for the initiatives selected for analysis. The use of these tools provides greater clarity about the business models employed, the vision of the actors responsible for carrying out the initiatives, as well as their respective strengths and weaknesses.

This article makes important contributions. Firstly, from a methodological and technical-managerial point of view, it proposes an analytical model for open innovation initiatives, proposing paths for future initiatives based on organizational learning. Secondly, it applies the proposed model to a nationally and internationally recognized organization, which will be able to take practical advantage of all the findings related to the analysis process and the proposal of paths, as well as demonstrating that the proposed model is viable.

2. THE CONTEXT INVESTIGATED

2.1 Embrapa

Embrapa, as a federal public research company, operates in the generation of knowledge and technologies aimed at national agriculture, playing an important role in Brazilian agricultural innovation. This is reflected in its mission to enable research, development and innovation solutions for the sustainability of agriculture, for the benefit of Brazilian society (Embrapa, 2024, p. 24).

Its role goes beyond providing technology, acting as an articulator of innovation in the local, state and national scenarios and in the context of the production chains in which it operates. This is quite evident from the fact that Embrapa was created as the leading institution in the National Agricultural Research System, with the intention of promoting agricultural research and the integration of institutions in the sector (Pereira and Castro, 2020).

Embrapa's structure includes Central Units, which define and facilitate the company's organizational systems and practices, and Decentralized Units (DUs), which carry out the innovation macro-process (i.e. research projects, public-private partnerships, open innovation initiatives, technology transfer, etc.), as well as administrative and management processes, in line with corporate guidelines, respecting the laws and regulations that govern the work of federal public companies. Embrapa currently has 43 DUs spread throughout Brazil, which can be classified as ecoregional, products and basic themes (Embrapa, 2022).

At the strategic level, the company has the Embrapa Master Plan (PDE), currently in its 2024-2030 edition, which directs all the activities to be developed by Embrapa (Embrapa, 2024). The Strategic Objectives in the PDE are interdependent and cross-cutting, which confirms the idea that the actions proposed in this article also make significant contributions to the Final Strategic Objectives, since the open innovation initiatives exist precisely to achieve them.

2.2 The contemporary process of innovation in organizations: open innovation and networks

The concept of innovation is constantly being revised and new concepts inserted, observing organizational practices. In this sense, open innovation has been gaining a lot of importance, since, for an organization, the use of ideas, learning and external knowledge, aimed at improving and/or enhancing its processes, can bring new elements to its innovative process, resulting in greater competitiveness in the market (Chesbrough, 2003; Lopes and Carvalho, 2018).

The study by Gassmann et al. (2010) highlights the need to develop or change the company's organizational culture, in order to understand that external skills and *know-how* are also sources of competitiveness for the organization itself. Furthermore, sharing knowledge and activities leads to lower development costs in the innovation process (Chesbrough, 2003).

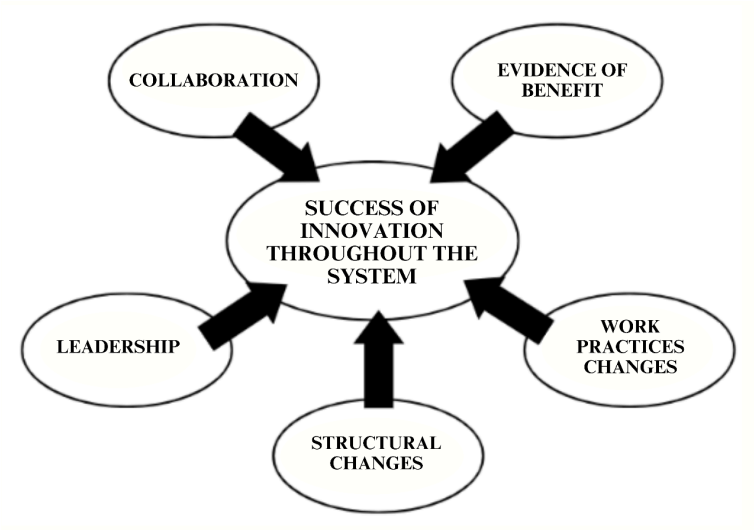
In this sense, the innovation process in organizations has been moving from a linear logic to something more complex. The study by Leeuwis and Aarts (2011) shows the evolution of important aspects related to this process. Since 1990, it has brought together different actors who participate in interactive co-creation movements, moving from a context with little interference and uncertainty, to something much more complex, which understands science as important, but as part of the process and not as the process itself.

Briody and Erickson (2014) present their system-wide model of innovation success (Figure 1), made up of five characteristics: collaboration, leadership, structural changes in the way the organization works, changes in working practices and evidence of benefit. The

proposed model can be seen below.

Figure 1

Characteristics linked to the success of innovation throughout the system (adapted from Briody and Erickson, 2014, p. 36)



In the results of the study conducted by Briody and Erickson (2014), collaboration between different organizational units is a fundamental element in sustaining the innovation process. It is possible to assume that the article by Briody and Erickson (2014), which focused more on the internal dynamics of an organization, can also be extrapolated to the dynamics of an organization's interaction with other institutions, in networking. In this sense, the same elements that reinforce benefits for the innovation process, such as collaboration and structural changes (the latter with a greater focus on changes that facilitate open innovation), also seem to be true.

Considering that the innovation process is part of the economic-productive process of an organization, this work has a strong connection with the sociological perspective, but above all with economic sociology, and it is worth acknowledging the work of Uzzi (1996; 1997) and Owen-Smith and Powell (2008), who understood networks as important means of expanding the value delivery of organizations.

However, internal relations, relations with other institutions and the composition of innovation-focused networks present major challenges. Among the main threats and barriers is the difficulty in interaction between the parties, which can diminish or even make it impossible to deliver the full potential.

2.3 Silo effect

The silo effect is directly related to the isolation and/or lack of interaction between the parts that make up an organization (Tett, 2015). According to the author, silos arise because human groups and organizations have specific conventions about how they understand the world, which can generate a misalignment with the rest of the organizational conformation.

The lack of integration is especially sensitive in the current context of an organization's innovation process. It is essential to understand that this process is increasingly interactive, going through processes of co-creation and co-development, as well as other key processes, which involve not just two institutions, but real networks.

Organizations are very concerned about the imminent existence of the silo effect in their value generation processes, creating strategies and mechanisms to avoid it. Situations involving advances in sustainability, for example, as is the case with Horan (2020), and various authors (Nilsson et al., 2016; Leiren and Jacobsen, 2018; Korfmacher, 2020), have also focused on studying the importance of breaking down silos in order to achieve sustainable development.

In the same way that sustainability agendas involve the involvement of different actors, for which it is necessary to create networking mechanisms and strategies, the situation is quite similar in an organization's innovation process, especially in open innovation movements. In this sense, the study by Favarin et al. (in press) demonstrates the existence of the silo effect in the implementation of open innovation programs at Embrapa, especially in the interaction between the DUs, requiring the creation of a networking mechanism (Favarin et al., 2024). Therefore, in addition to the networking mechanism, it is necessary to instrumentalize networking, which is why this work was developed.

3. DIAGNOSIS OF THE PROBLEM SITUATION

In the second half of 2023, In 2023, a survey was applied to map the open innovation initiatives promoted by Embrapa's Decentralized Units. At this stage, a questionnaire has been sent to all the DUs.

It was identified that between 2018 and 2023, the DUs carried out 31 open innovation initiatives. Of these, only 5 (16%) were developed in a network between the Units. When we consider the initiatives promoted with external partners, there were 19 (61%), covering other ICTs, companies, innovation environments (accelerators, incubators, hubs, etc.) and government bodies. Furthermore, of the 43 DUs, only 21 (around 50%) had some kind of involvement in initiatives of this nature.

It is important to understand that Embrapa's 43 decentralized units have different and complementary focuses, depending on their research themes and the ecosystems in which they operate. The issue is even clearer if we consider the great evolution of Brazilian agriculture in recent decades, both in terms of production and complexity. This situation raises some questions, such as: What is the motivation for open innovation initiatives? What are the limiting factors? What is the reason for the lack of open innovation initiatives in networks between units? Can the units understand how to act, what the objectives and expected results are?

Therefore, it is important to understand in greater depth the different types of initiatives that have been carried out by Embrapa centers, whether in partnership with other DUs and/or external partners or not. To this end, a multiple case study was conducted focusing on Embrapa and, based on the analysis of open innovation initiatives, it was possible to understand what the current situation is and propose a guideline for modeling new paths, which will facilitate the implementation of new initiatives, as well as enabling the process to evolve.

This study was guided by the methodological steps described below:

1. Establish criteria and select the cases to be analyzed, taking into account the data recorded on the form;
2. Apply Business Model Canvas and SWOT Analysis to evaluate each of the selected initiatives;
3. Conduct interviews with the DUs responsible for the initiatives and with Embrapa's Business Department;
4. Propose new ways of carrying out open innovation initiatives.

In order to take into account diversity in terms of the type of initiative and the region it covers, and using the initiatives mapped in 2023 as a basis for selection, the criteria for selecting innovation initiatives can be seen in Table 1 below.

Table 1

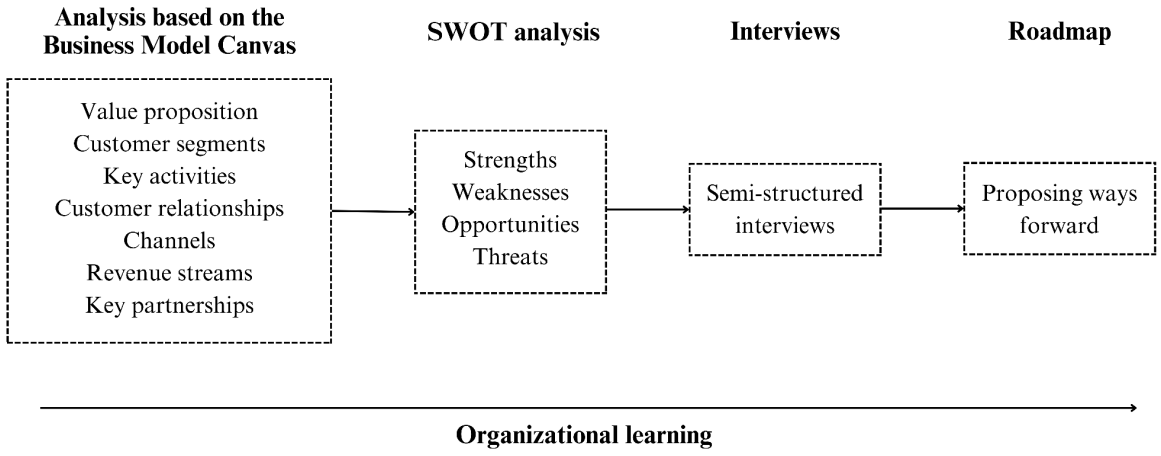
Initiatives selected

Initiative Name	Partnerships in the initiative	Responsible Unit	Type of Initiative	Region
Initiative 1	No involvement of DUs or external partners	Unit A	Public Notice	South
Initiative 2	No involvement of DUs or external partners	Unit B	Innovation Pitch	Center West
Initiative 3	With the involvement of DUs and external partners	Unit C	Connection event	South East
Initiative 4	With the involvement of DUs and external partners	Unit A	Mentoring/acceleration	South
Initiative 5	No involvement of DUs, but with external partners	Unit D	Announcement / Connection event	South
Initiative 6	No involvement of DUs, but with external partners	Unit E	Hackathon	North East

To carry out the analysis and propose the roadmap, a model was built (Figure 2). It materializes the organizational learning process, since it establishes a logical line that allows the institution to learn from its experiences.

Figure 2

Visual representation of the analysis model proposed in the article (author's own work)



3.1 Analysis of the business model of open innovation initiatives

The analysis was made in a cross-referenced manner, which not only analyzes the strengths and weaknesses identified in the specific initiative, but also presents the similarities and differences between the initiatives through comparative analysis. Tables 2 and 3 show the points analyzed, with information on each initiative.

Table 2

Analysis of innovation initiatives in terms of value proposition, customer segment and key activities in the

	Value proposition	Customer segments	
Initiative 1 Public Notice	Provide opportunities for co-development or improvement of solutions, with TRL between 4 and 7, with Embrapa as a technical partner	Startups with an active CNPJ and that are developing solutions with TRL between 4 and 7, in the topics covered by the call for proposals	Preparation of the call for confidentiality agreement; i present the proposals); Exec POCs and validations in labo
Initiative 2 Innovation *pitch*	Bringing Embrapa closer to the productive sector through presentations of technologies, with a view to establishing partnerships for co-development.	Companies of all sizes working in the areas covered by the initiative.	Articulating internally and v Planning for the reception of
Initiative 3 Connection Event	Provide access to qualified knowledge, generate networking opportunities and partnerships.	Universities; Startups; Companies; Innovation Environments; ICTs; Entrepreneurs; Industries.	Articulation with partners Dissemination; Programmi Transmission platform.
Initiative 4 Mentoring / Acceleration	Receive support from mentors and experts, content and events, to develop or scale products and services, and may receive a contribution of up to 50 thousand dollars	*Startups* or academic *spin-offs* with a developed Minimum Viable Product (MVP)	Definition of partnerships/ar the call for proposals; Launc proposals; Announcement program, with deliveries: fo connections and *workshops*
Initiative 5 Announcement/ Connection event	Bringing together companies, institutions and other players in the ecosystem to co-develop open innovation projects with Embrapa, with the possibility of receiving financial support.	Startups, especially more mature ones; Companies related to the chain; Companies and research institutions;	Survey of chain demands; Definition of criteria and d proposals; Analysis and se Signing of confidentiality ag proposals; Signing of specifi
Initiative 6 Hackathon	Fostering the agricultural innovation ecosystem in the region on an ongoing basis	Agricultural startups, as well as students and professionals (management and business/agriculture/IT)	Survey of the region's mai themes for the call for prop for proposals; Workshops (*pi*

All the value propositions, some directly and others indirectly, set out to leverage the development of technologies. This is understood to be related to Embrapa's institutional mission. The value propositions can be grouped into three categories:

1st Category: Focus on promoting discussions for a sector or ecosystem;

2nd Category: Focus on fostering the ecosystem as well as entrepreneurship; and

3rd Category: Focus on co-developing technologies.

The value propositions are also associated with Embrapa's role as a player in the National Agricultural Research System (SNPA) and the National Science, Technology and Innovation System (SNCTI). ICTs contribute to promoting connections between the various links that make up the systems and Embrapa generates value beyond its role as a company that develops innovations.

The different initiatives also show Embrapa's decentralized and broad nature, since the DUs are part of heterogeneous innovation ecosystems at different stages of maturity, requiring different strategies. It is therefore natural that the types of open innovation initiatives vary.

The initiatives are generally led by the technology transfer (tt) areas, with less involvement from research. In this sense, it is important to note the risk of innovation initiatives becoming a parallel agenda of the tt areas and, in order to avoid this, it is essential to establish direct connections between the initiatives and the RD&I (research, development and innovation) management of the DUs.

With regard to the initiatives' customer segments, although they are broad and heterogeneous, which demonstrates the company's great ability to engage in dialog with different players, they are all part of the innovation ecosystem on the theme of each initiative. In this dialogue with the different audiences, it is also important to highlight the importance of involving external partners, due to their significant role in publicizing and mobilizing participants.

Interviewee 5 reports this involvement with stakeholders and public interest groups to identify priority themes:

> We held strategic seminars with specific groups and themes. We managed to get a lot going. Based on these external surveys, we defined innovation priorities. All the moments were well articulated with other institutions, including the pre-selected ideas.

In general, the key activities were planned and executed according to their nature and specificity. However, as a common point, there was once again a need for awareness-raising and internal coordination, with a view to the support and commitment of the teams, especially managers and technical staff, for their success.

The planning and execution of all the initiatives involved the events process. This point deserves special attention, since an indirect benefit for the Units seems to have to do with visibility, which is a positive aspect, but it is essential that the initiatives generate steps connected to the company's business.

Of the six initiatives studied in this case, four are recurring and two were one-offs. In the recurring initiatives, the team's learning was noticed, with an increase in maturity and clarity about the process, as well as the improvements implemented.

Table 3

Analysis of customer relationships initiatives, channels, revenue streams and partnerships

	Customer relationships	Channels	Revenue streams	
Initiative 1 Public Notice	Website; E-mail; Face-to-face and virtual events; Social media	Distance (mentoring) and face-to-face (mentoring, POC and validations)	Embrapa is not directly remunerated. Embrapa may receive royalties from technologies	Realization: Directorate (I (CTI), DU communicati
Initiative 2 Innovation *pitch*	E-mail announcements and invitations to the target public; the Unit's website; - Social media	- Face-to-face (presentation of DUs research, round of negotiations and visit to facilities)	Embrapa is not directly remunerated. Embrapa may receive royalties from technologies	Realization: sectors of the
Initiative 3 Connection Event	E-mail; Telephone; Social media; Network website; Embrapa portal; YouTube chat; Partnership form; Contact with experts.	At a distance (Youtube Embrapa).	Embrapa is not paid directly.	Realization: Network; Su hub and 1 Embrapa's C and 4 DUs (tt
Initiative 4 Mentoring / Acceleration	*Website; E-mail; Roadshow;* Social media	In person and at a distance: accompaniment, support and immersion in the *Hub*, mentoring, connections and *workshops*	Embrapa is not directly remunerated. Embrapa may receive royalties from the technologies generated	Realization: DUs, a pub companies. E research cent
Initiative 5 Announcement/ Connection event	Social media; Embrapa portal and DU websites; *Lives to* publicize; Face-to-face events	Conducting proposals in person and remotely (mentoring, research structure, search for funding, etc.)	Embrapa is not directly remunerated. Embrapa may receive royalties from the technologies generated	Realization: a city hall. S class council. CTI of DU, re
Initiative 6 Hackathon	Embrapa portal and DU website; *E-mail;* Social media; *WhatsApp* group; *Lives*	Virtually, through workshops on the YouTubel channel	Embrapa is not directly remunerated	Realization: A the creation agriculture se

When it comes to customer relations, virtual resources and channels are used extensively, allowing for greater reach, even among those who are more geographically distant. In all the initiatives, there was a concern to maintain a more lasting relationship, although not all of them were able to continue. This is due to a lack of financial resources, limited teams or other management priorities, as well as the lack of a catalyzing agent in the ecosystem, or even the lack of a long-term strategy thought out and structured from the start of the initiative.

For the initiatives that sought to strengthen relations through the development of RD&I projects, it was evident that partnerships were being formalized through the signing of legal instruments, such as Confidentiality and Technical Cooperation Agreements, following Embrapa's innovation macro-process and the institutional guidelines for research projects and their types.

With regard to distribution channels, a large number of the initiatives were delivered remotely, which increases their reach and reduces costs, while others were delivered face-to-face, mainly with a focus on co-developing technologies. The delivery channels chosen seem to be quite appropriate considering the initiatives' objectives.

Another interesting point refers to the sources of revenue, where most of the initiatives are not monetizable. Considering that the initiatives studied have the direct or indirect objective of fostering open innovation in the ecosystems in which Embrapa operates and that, to this end, they rely on the collaborative work of various actors, without direct transfers of resources, contributing mainly with their human resources, monetization would not be the goal of these proposals. Interviewee 1 addresses this issue:

> The first big gain is being a protagonist in an innovation hub that brings learning, contact with startups and innovative technologies. Having the Embrapa brand there is important. They needed technical people to evaluate the projects (agronomy specialists). In return, we began to be part of the process, to have access to the innovation trails.

However, everyone involved wants the initiatives carried out to somehow generate a financial return for the company. For Embrapa, the main source of income identified was the possibility of collecting royalties from the technologies to be developed. It is understood that these are expected future impacts and are not the momentary sources of revenue for the initiatives.

Even though it wasn't the direct objective of the proposal, one of the initiatives studied (5), presented as a source of income the sponsorship quotas received to make it possible to hold the event to integrate the chain and present the finalists. This was an interesting point for raising revenue, because according to the organizers, the financial resources not used in the current year are invested and can be used in the following year, or even in other innovation initiatives to be promoted by the Unit.

3.2 SWOT analysis of open innovation initiatives

Understanding the strengths and opportunities is fundamental to understanding the main positive attributes related to open innovation initiatives. The information on the 6 initiatives can be seen in Table 4.

Table 4

Survey of the Strengths and Opportunities of the Initiatives analyzed

Forces	Opportunities
1. the strong reputation of Embrapa and the Unit involved and the recognized technical capacity of the Unit, which attracts startups that need to develop or increase their technologies 2. DU has internal competencies to structure and conduct the action 3. pioneering an open innovation initiative (willingness to take risks) 4. involvement/support of the RD&I manager in the action 5. there is a platform/group focused on innovation and digital agriculture 6. approved research projects that subsidize the thematic lines of the calls and Embrapa's costs 7. institutions with complementary capacities and internal competencies to structure and conduct the action; 8. Embrapa's role, as an ICT, to be an orchestrator of discussions, due to its expertise, and recognition of this function by the entire chain; 9. triple helix participation in the proposed initiative. → The proposal was easily "bought into" by the different links in the chain; 10. support from the municipal and state authorities to carry out the initiative; 11. the participation of experts in different fields, even on conflicting issues, for discussions based on scientific and real data; 12. a new policy for evaluating the Units with a view to integration actions, which could lead to an increase in network actions; 13. initiative with financial resources that can be allocated to startups; 14. the Unit's experience in innovation initiatives.	1. capture proposals for innovations that complement what is being developed in research projects 2. forming partnerships with dynamic players (startups) in the innovation ecosystem 3. consolidating DU's presence in the cultural innovation ecosystem 4. crops with commercial relevance, with robust ecosystems and attracted to promote innovation actions; 5. capitalize on the exploitation of the assets generated in partnership in the contracts 6. Embrapa's technology into commercial products and partners' technological packages 7. bring together different expertise from the different links in the chain → get the pains and solutions on the same table so that they can discuss and identify possibilities for alignment and solutions 8. development of technological solutions with greater potential for adoption and impact on the market 9. identifying and proposing relevant changes in the production chain quickly and effectively. In particular, in relation to changes in consumption patterns and legislation; 10. support for programs related to Public Policies; 11. The state's innovation ecosystem is in a growth phase, with players willing to engage in this type of initiative.

It can be seen that Embrapa's credibility in the innovation ecosystem is one of the major factors in bringing together the different players in the ecosystem, and the possibility of accessing the technologies and knowledge generated by Embrapa arouses great interest. From an institutional point of view, the advantages of Embrapa's inclusion in innovation environments and in initiatives that involve networking, whether internal or external, are great, since it contributes to increasing the company's visibility in innovation ecosystems, accelerating the process of cultural change, improving organizational learning and the maturing of the internal RD&I team on issues related to innovation, as well as capturing and exchanging, in real time, the needs and expectations of the market and of research.

Among the gains obtained from the initiatives carried out is the inclusion and visibility of the Unit in the regional innovation ecosystem. In addition to this perception, as a government agent, Embrapa has the role, and is perceived by its peers in this way, as one of the orchestrators of innovation networks around different production chains. This fact is mentioned in the study conducted by Castro et al. (2018) analyzing the role of networks, where government agents can act as supporters in the creation of innovation networks,

promoting the meeting and synergy between different actors, seeking potential partnerships between them, by stimulating public incentive policies and programs, providing information, among others.

We must take into account and respect the level of maturity of the decentralized units in the innovation process, which has a strong influence on the engagement of managers and teams and on the design of strategies, definition of objectives and gains, as well as their participation in the ecosystem and relationship with its various players. Interviewee 4 elucidates this aspect:

> You have to want to do it. There's no point in forcing it. You need to monitor the evolution of the process. It doesn't have to be mandatory, but you have to give support to those who want to do it. (...) The Units that want to do it will seek it out. They go to Headquarters, to other DUs, they start, they make mistakes, they get it right, until they find their way. Headquarters' role is also to look outside and connect, to bring experiences to Embrapa. There are different calls, different types of connections and contributions. It's important to listen to the pains of the Units and present ways forward, alternatives to what has already been done, in order to reduce errors.

Another positive factor identified is the change in the way the decentralized units are evaluated, where the indicators relating to internal partnerships are currently valued by the company, seeking greater integration between its research centers, which leads to greater interaction between them and different environments and innovation initiatives outside their comfort zone of operation (region, biome, production chain), due to the structuring and strengthening of internal networks. Interviewee 4 raises a question for reflection:

> Is the low level of interaction only due to innovation initiatives or does it already come from Embrapa's agenda? It's a point that precedes the initiatives. (...) I only turn to another Decentralized Unit when I don't have the know-how. When we deal with the same subject, we each do our own thing, with our backs to the other. In terms of networking, we still have a long way to go and the Research, Development and Innovation Directorate plays a very important role.

For years, the company maintained a competitive form of evaluation between its Research Units, which, by standing out according to the proposed criteria, guaranteed more resources for their agenda. This disintegrated and discouraged the formation of joint agendas between the Units, which often opted for external partnerships rather than using the internal skills available.

The recent revision of this evaluation process, which includes the formation of internal networks among the criteria, is seen as an opportunity for greater joint action in innovation initiatives.

Still on the subject of opportunities, interviewee 4 raises a question for reflection:

> We need to move on to a second stage of interaction with the ecosystem. Online model. Artificial intelligence system on a streaming platform (e.g. Israel), with real-time interaction. Germany has something like this too. Some universities in Brazil already do this: entrepreneurial researchers. If the researcher isn't monitored in the first few years of the project, it sometimes dies... this is an incentive for the generation of new startups. The best laboratories end up being in institutions that do this.

This leads to some important questions for planning that mobilize Embrapa's future actions with the environments and their players in the innovation ecosystem: what are we really looking for? What kind of collaboration and participation can and should Embrapa offer? How can it provide effective support? How can it be a catalyst? And more than that, how can the actions carried out be more effective and efficient? What indicators and metrics will be used to demonstrate the importance of this action? As with the previous item, this is a great opportunity for Embrapa to demonstrate its relevance as a catalyst, orchestrator and

manager of the ecosystem, playing a significant role in sharing knowledge, transferring technology or jointly developing innovations for the market with the productive sector. But at the moment, it can still be seen as one of its weaknesses and threats because it is unable to have this structured data, and as presented the event is finished in itself, without a critical analysis of it and continuity of the relationship with the partners.

Weaknesses and threats are points of attention that need to be analyzed and dealt with. These two aspects are described for each of the initiatives in Table 5.

Table 5

Survey of the weaknesses and threats of the initiatives analyzed

Weaknesses	Threats
1. lack of partners (companies, innovation environments, etc.) that could complement each other and increase the impact; 2. the action did not provide financial resources for the startups; 3. expectations that differ from reality in terms of the time it takes to deliver innovations; 4. The initiatives and projects selected are not as closely linked to the institutions' RD&I agendas; 5. there is no opportunity cost study; 6. changes in company management often bring abrupt changes in the initiative's proposal 7. selected projects are not converted into agreements and/or adopted assets; 8. lack of monitoring of the technologies that will be presented in these initiatives, so that those that are considered most promising are selected; 9. lack of institutional support with possible financial contributions and publicity to make the initiative more robust; 10. difficulty in coordinating different teams; 11. lack of internal structure → "Disconnection of agendas" between teams, boards and discussion spaces - SILO EFFECT; 12. the agenda of innovation initiatives is individual (people or Unit) and not institutional → "the initiative dies within itself"; 13. lack of professionals with knowledge of innovation (environments and networks) and communication for innovation; 14. RD&I teams are not always connected with proposed innovation initiatives, and make informal agreements with other players; 15. there is still a culture of competition between the units, 16. lack of logistical and financial structure to make possible matchmaking and other more dynamic actions that generate business and real action. 17. difficulty in the business and "post-event" actions, with analysis of the results, maintenance of the connections/relationships established and future potential; 18. high transaction costs, especially in terms of human resources;	1. evasion of mentored startups when they become businesses; 2. third-party calls for proposals with more attractive value (e.g. with the release of funds), leaving Embrapa with startups with low market potential; 3. environments and sector become restrictive to new Embrapa actions→ Do not identify *Win Win,* as it is not an institutional action and presents absence/difficulty of subsequent responses; 4. other ICTs or companies to occupy Embrapa's space as a protagonist in transforming the system and bringing together relevant discussions for the chain; 5. same startups and ecosystem players taking part; 6. lack of a catalyzing agent to give continuity to the initiatives in the ecosystem; 7. shadowing the Unit's EMBRAPII projects, especially those related to the availability of new assets for the market.

Weaknesses	Threats
19. companies propose service projects rather than co-development; 20. large number of innovation challenges proposed in the last call for proposals, which makes management more complex; 21. improving the definition of which partners are sought.	

In general, the weaknesses reveal aspects related to the level of maturity of the Units in the innovation process. For some units, their high level of maturity is a strength, while for others, their low level of maturity is a weakness.

There were reports of internal difficulties such as lack of team experience, coordination of teams and agendas, support from senior management, competition between Units and the selection and prioritization of promising technologies, and other external difficulties such as the lack of partners and the connection between the Unit's RD&I agenda and that of the partners. Financial resources are also a sore point, limiting opportunities to continue the initial movement. Interviewee 2 mentions some of the points raised:

> (...) lack of something institutionalized, a document; no participation from Headquarters, sometimes the researcher declines halfway through; need for the Head to be really involved in the process; availability of minimal financial resources (snacks). Resources sometimes from the Head Office, "crowdsourcing" resources from the researcher's project; the location of the DU also gets in the way a bit, because the customer segments are not in the state, so it's difficult to get them there. (...) Asset generation: companies want assets with more advanced maturity, from the middle to the end. Difficulty with early TRL assets.

Interviewee 1, on the other hand, reports points more related to creating, proposing and capturing value from initiatives, without well-defined strategies, raising questions such as, "what does Embrapa want? What does it expect? What do the RD&I teams understand and see as value?

> Another thing is to know how far Embrapa wants to go. This alignment with research, before actually entering headlong into a relationship, is important. Where does the research fit in? The researcher has to see value....learned. Bringing the startup in to work together? Projects. What can Embrapa incorporate? The important thing is to try to link the challenge with the pains of the Unit's researchers, because there are lots of hackathons and other initiatives, but it's important to understand what this will bring to the DU.
>
> A critical but deeply reflective statement was made by interviewee 4:
>
> The TCU issued a ruling criticizing Brazil's progress in the innovation ranking, with very dispersed initiatives by institutions. (...) Along with Radar Agtech, to what extent has the call for innovation initiative model not reached its maximum? To what extent are they the same startups? We're no longer at the point of going one step further with new generations, with the need for faster responses. Calls and initiatives are still very important, but much more in terms of visibility than results. The good startups have already found their way... I don't think the modus operandi model that we already use has much further to go, but if we add new forms, new tools, with other alternatives for connecting with these players, models that can lead to a new phase of connection.

This observation calls for an in-depth analysis, in an institutionalized manner, of the results that are being obtained through the different initiatives promoted, and how to make

them more interesting for new entrants/players in the customer segment of interest, as well as the real results obtained.

As mentioned, the lack of indicators and metrics after initiatives limits the analysis of the effectiveness of current initiatives and the possibility of improving them.

Within the SWOT analysis for the weaknesses identified (Table 5), some mitigation or treatment actions are indicated, such as:

1. Strengthening actions to encourage a culture of innovation with the RD&I team (training, lectures, workshops, talks), especially in innovation environments, with a view to changing the *status quo* and identifying new opportunities, mechanisms and sources of potential funding for the development of new projects;
2. Mapping of innovation environments and their players, in order to create initiatives that meet their expectations and needs, including the possibility of building joint business plans for future initiatives that have financial support from important players in the ecosystem, both in terms of encouraging the development of technological solutions and sponsoring initiatives;
3. Knowledge management and organizational learning: virtual space for storing information related to the implementation of innovation initiatives, for sharing step-by-step and good practices to be followed, as well as strategies that should be avoided; Learning trails.
4. The composition of multidisciplinary teams, with well-defined roles in terms of execution and dedication time, together with the support of other Units or Embrapa Headquarters in the planning, execution and monitoring stages would be assertive for the lowest transaction cost of the initiatives, including their results, performance and impact indicators.
5. When calling for initiatives, clearly present the desired customer segment and the expectations for its realization. In the case of co-development, be clear and explicit about the next steps to be taken, including assertive information on intellectual property issues and commercial exploitation rules, in order to reduce the frustration of expectations and the breakdown of relationships at later stages of development.

With regard to the threats reported, there is the risk of other ICTs or even private companies taking on the role of protagonists within the ecosystem, considering the difficulty of Embrapa continuing its actions and the existence of more attractive initiatives for participants. Added to this is the very volatility and maturity of innovation ecosystems. Many of the innovation environments, for example, which are actors that Embrapa has a lot of interaction with and have been mapped by Embrapa, have undergone changes in their management or operating model in recent years, which makes it even more difficult for Embrapa to adapt and respond quickly to these changes.

Another point of attention refers to the location of the decentralized units, which are often very far from the players in their chain of action, as noted in the report by interviewee 2."The location of the DU also gets in the way a bit, because the public isn't in the Federal District, so it's difficult to get them there."

This fact only reinforces the importance of networking between Embrapa's decentralized units, because as we have already seen, the environment sees Embrapa as a major player, rather than a specific unit. From the observations, it is possible to infer that not only is the level of maturity of the Unit involved directly related to the threats reported, but also the lack of financial resources for the initiatives makes it difficult to continue them, as well as to promote more attractive offers. Interviewee 6 reports limitations related to these aspects:

> It didn't continue. The idea was to do pre-incubation and then incubation. Partner X was going to provide training for the startups, but then decided to charge. The manager

also agreed to pay for it, but couldn't follow through. There were no financial resources. If they had, it would have been better, there would have been more public engagement.

As for the threats identified (Table 5), some mitigation or treatment actions were indicated, such as:

1. mapping the initiative's results and performance indicators in order to strengthen it as a corporate strategy, which must be maintained regardless of changes in management, as it is based on strong links with stakeholders and results in the chain.
2. have indicators for monitoring and mapping the initiative's participants, in order to bring in new participants, as well as identifying the need for changes in the initiative's structure or format, in order to remain relevant to the different links in the production chains involved.
3. building a communication plan focused on the different players in the innovation ecosystems; building relationships with these players; conducting research with startups that participated in the call for proposals to understand their perceived value; offering significant value; presenting the startups to accelerators (as a continuation of the process) would be interesting.

Based on the analysis presented, the proposal to draw up a guiding document is also a response to the weaknesses and threats. In this way, units that have never promoted any innovation initiatives or those that are going to promote new initiatives, in different formats, will have greater clarity, mitigating the negative points and enhancing the strengths and opportunities.

4. PROPOSED INTERVENTION

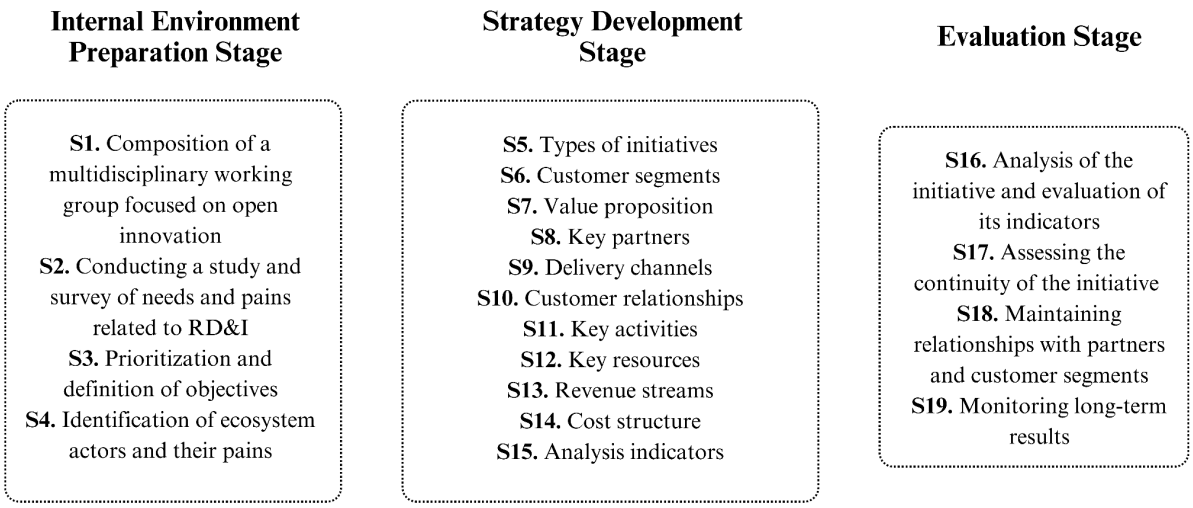
The analysis of open innovation initiatives allowed us to propose paths, generating a roadmap for carrying out actions of this nature. According to Treitel (2005), roadmaps are simplified graphic representations that make it possible to effectively communicate and share a strategic intention with a view to mobilizing, aligning and coordinating the efforts of the parties involved to meet one or more objectives. They structure strategies and bring their development, the exploration of paths and the monitoring of steps required to reach a given objective into an operational field.

Thus, in the context of this work, the roadmap proposed for the construction of new open innovation initiatives in the Embrapa environment (Figure 3) reflects the work of exploration and qualitative analysis of the initiatives already carried out, especially in the contributions arising from the difficulties and weaknesses identified, among which the absence of a guide or guiding process was one of the shortcomings pointed out. In view of this, the proposed tool, shown in Figure 3, contains the steps to be followed.

The tool proposes the milestones that are considered essential for the successful construction of open innovation initiatives by Embrapa's units. However, these are not mandatory or sequential stages, which may take place concurrently or in different orders, understanding that this is an organic and dynamic process. The description of the steps, described in Figure 3, will be detailed below.

Figure 3

Proposed roadmap for open innovation initiatives (author's own work)



Internal Environment Preparation Stage

Steps 1, 2, 3 and 4 are part of a structuring and strategic approach to actions related to the innovation process. They are proposed as initial stages, i.e. they must be done before the open innovation initiatives are implemented.

The first step (Setting up a multidisciplinary working group to think strategically about open innovation) involves setting up a permanent, multidisciplinary team, with good representation from the research and technology transfer areas. The team should work on building, applying and sharing knowledge about open innovation in the Unit, including the governance of all the steps presented here, as well as carrying out actions to strengthen the culture of innovation and create mechanisms for organizational learning.

With regard to the second step (Carrying out a study and survey of needs and pains related to RD&I), one of the key points for the success of innovation initiatives is alignment with RD&I agendas, focusing on the needs and pains perceived by the technical team. This stage includes: analysis of the Unit's portfolio of assets, identifying those that need partnerships in order to achieve greater scales of maturity (TRL); and analysis of Embrapa's existing capabilities and those needed to achieve the results expected from research projects.

In the third step (Prioritization and definition of objectives), based on an analysis of the Unit's internal pains and needs, it is suggested to prioritize and define the objectives to be pursued in the short, medium and long term, establishing a logical line of work. Many Units have carried out open innovation initiatives without completing steps 2 and 3, which can lead to disarticulation and conflicts within the Unit, especially between the research and technology transfer areas, as well as limited deliveries that are tangential to the Unit's agenda.

The fourth step (Identifying the actors in the ecosystem and their pains) is very important, given the importance of understanding the actors in the agricultural innovation ecosystem, as well as their pains, in order to align with the objectives established within an open innovation program or initiative. As this is a hot topic, many studies are being executed, as is the case with Radar Agtech Brasil, and a literature search may be sufficient. Examples of relevant actors to be mapped: 1. Other Embrapa decentralized units; 2. Startups; 3. Governance of regional and sectoral innovation ecosystems; 4. Innovation-promoting

environments (hubs, incubators, accelerators, technology parks, farm labs, etc.); 5. Institutions working with entrepreneurship and business management; 6. Government, government science and technology institutions and other scientific research institutes; 7. Private companies that have synergies with the established objectives; 8. Universities and public and private intelligence centers; 9. Industries, cooperatives and associations; 10. Development agencies, financiers and investors; 11. Civil society organizations promoting economic and social development; and 12. Other players in a region or production chain.

Strategy Development Stage

From the fifth to the fifteenth step, the aim is to structure the open innovation initiative's business model. To instrumentalize this process, an adaptation of the Business Model Canvas was developed, which contains new fields and questions to guide its completion, as can be seen in Figure 4.

Figure 4

Business Model Canvas for the Development of an Open Innovation Initiative (adapted from Osterwalder

<table>
<tr><td>S8. Key partners

What capabilities does my Unit have and what others are needed to carry out the initiative? What are the complementary institutions? Which other Embrapa units are working on topics related to the initiative? What are the partnership projects between the Units?</td><td>S11. Key activities

What are the key activities for delivering the value proposition and results? Are they feasible? Have those who will carry them out been sensitized? Are the activities being worked on with integration between those who will carry them out?</td><td rowspan="2">S7. Value proposition

What value will the innovation initiative deliver? Will the value delivery be just one or will it be fragmented?
What differentiates the initiative's value proposition from that of other institutions?</td><td>S10. Customer relation

What are the most effici
relationship to reach the
segments? Are there imp
potential partners to giv
the initiative? What are
relationship to maintain
with customer segments
initiative?</td></tr>
<tr><td>S5. Types of initiatives

What objectives are prioritized? Are you looking for technologies that have started to be developed by partners or will you offer technologies initiated by Embrapa? Are you looking for technologies in early or more advanced TRLs?</td><td>S12. Key resources

Which teams are involved in the initiative? Does the initiative require the use of equipment, virtual platforms or physical space?
Will the initiative require the use of financial resources?</td><td>S9. Delivery channels

Will there be just one de
channel or several? Wh
benefits of using face-to
remote channels? Are th
channels suitable for the
segments and objectives</td></tr>
<tr><td colspan="2">S14. Cost structure

What will the costs be to carry out the initiative? Does the Unit have all the necessary structure? Would the Unit need to hire someone or some kind of service?</td><td colspan="2">S13. Revenue streams

Should the initiative generate revenue? the initiative require financial resources</td></tr>
</table>

As shown in Figure 4, it is possible to follow a logical line for modeling open innovation initiatives. It is worth noting that it is possible to reconcile different types of initiatives or to make one initiative with several approaches, including:

- acceleration: focus on accelerated business growth, which tends to happen with startups with at least intermediate maturity (TRL);
- public notice: this is the means by which the organizer establishes the general guidelines (themes, stages, selection criteria, profile of applicants, benefits, etc.) and is often accompanied by events;
- connection event: enables interaction between different players who are part of the same sector, activity and/or are in the same region, but who find it difficult to establish a relationship;
- hackathon: an immersive event in which teams tackle challenging issues for a limited period of time, usually less than a week;
- incubation: focuses on structuring the business and tends to happen with startups with lower maturity (TRL);
- mentoring: this is when a professional passes on their knowledge to a person or team, usually as a step in an initiative; and
- pitch: a short presentation, usually lasting 3 to 5 minutes, to sell an idea, project or business, and is usually one stage of an innovation initiative.

There is a strong connection between all the steps described in Figure 4. In this sense, it is essential to first establish the type of initiative that will be developed and then consider the customer segments, the value proposition, the key partners and all the subsequent fields. Finally, the fifteenth step is the definition of the analysis indicators, which paves the way for the Evaluation stage.

Evaluation Stage

Steps 16, 17, 18 and 19 come after the open innovation initiative has been executed. As such, they play an important role in analyzing what has been done and establishing what the next steps will be.

Step16 (Analysis of the initiative and evaluation of its indicators) provides for the evaluation of the initiative, with the participation of the collegiate and the implementers, as well as key partners. Important questions that can be asked: Have the objectives set been achieved? How are the indicators that have been defined? How satisfied are the internal team, the ecosystem players and the customer segments? What are the points for improvement?

Step 17 (Assessing the continuity of the initiative) is necessary, especially for recurring initiatives - or those that may become so. To support this decision, some elements need to be analyzed: Did the format of the initiative meet expectations? Were there any unforeseen results? Were the key partners chosen correctly? Are there new partners that need to be brought in? Were the problems and needs solved in time? Is there interest in holding other editions?

With regard to step 18 (Maintaining relationships with partners and customer segments), maintaining relationships with partners and customer segments is essential and can be done in different ways. There is no perfect model and building relationships will depend very much on the type of audience and partners you want to maintain ties with, as well as the most efficient forms of communication for this segment.

Finally, in step 19 (Monitoring long-term results), it is important to be clear that most open innovation initiatives, especially those aimed at co-developing or scaling technologies, will show effective results in the medium and long term. This is because the initiatives play an important role in increasing the company's value deliveries, with the complementarity of new

players, but they don't happen as if by magic, in other words, it is necessary to align and be very clear about the co-development time of the technologies.

5. RESULTS

As shown above, the proposed paths taken in this article, materialized by the Roadmap (Figure 3) and its respective details (Section 4), are the result of the analysis of real cases experienced by different Embrapa Decentralized Units. Therefore, although some of the steps presented in the Roadmap are already practiced by some of the DUs, others were presented as suggestions that could contribute to improvements in the process.

In this sense, the 4 steps related to Preparing the Internal Environment were only made by the DU that developed open innovation initiatives 1 and 4, and the results are clear. The composition of a multidisciplinary working group to think strategically about open innovation was fundamental for the Unit to evolve within the theme and allow it to develop the other steps, i.e. carrying out a study and survey of the needs and pains related to RD&I, as well as prioritizing and defining objectives and identifying the actors in the ecosystem and their pains.

This same Unit even demonstrated greater clarity and objectivity in the preparation of steps related to Strategy Development. Since the open innovation initiatives were conceived as part of the DU's strategy, this even allowed more than one initiative to be promoted, with different and complementary focuses.

Still on the subject of the Strategy Development stage, it is worth noting that all the Units showed special attention to the steps related to it, with very clear definitions for almost all the items, especially for the initiatives carried out more than once. The exception is the definition of Analysis Indicators (Step 15), with few DUs showing clarity about what they are - among the exceptions is the DU that promoted initiatives 1 and 4.

The absence of clear analysis indicators has a negative impact on the Evaluation Stage. In order to carry out the analysis, it is essential to evaluate the indicators and then decide whether or not to continue with the initiative and monitor the long-term results. This is a particularly important point, which is to be able to calibrate expectations and what the chosen type of initiative is actually capable of generating.

The results obtained are partial and that once the Roadmap has been properly internalized, new results will be observed. At the moment, the results shape the organizational learning process, based on the initiatives developed by the DUs, and will be improved through their use in new initiatives.

6. TECHNOLOGICAL AND SOCIAL CONTRIBUTION

This article, based on a multiple case study of six open innovation initiatives carried out by Embrapa's decentralized units between 2018 and 2023, makes an important technological and social contribution to the study and management, from an applied point of view, of open innovation in organizations. The contributions are directly related to the general objective of the work and the specific objectives, since both the methodology for analyzing the initiatives and building the roadmap, as well as the roadmap itself, can be used in future studies, as well as by professionals in organizations, with possible adaptations.

In this sense, the methodology used, shown in Figure 2, proved to be very useful in instrumentalizing the analysis and construction of the roadmap, enabling organizational learning. In this way, the authors of this work understand that the process can be replicated in other organizations and studies, with possible improvements from a theoretical and contextual point of view.

With regard to the roadmap generated, although, depending on the nature of the organization and its business, there may be significant changes to the steps, it is understood that the 3 stages that bring the steps together can be extrapolated. As such, the authors argue that good open innovation management goes beyond the development of the strategy, and that it is necessary to prepare the internal environment and carry out evaluations.

It is also worth noting that Embrapa's units have been making efforts and seeking, in various ways, to connect more and more with the players in the innovation ecosystems in which they operate. On the one hand, some DUs show a more advanced level of maturity in terms of open innovation practices, while others are still at an early stage of maturity and are therefore struggling to start this process. The Units that have a higher degree of maturity have built up their open innovation initiatives with the involvement of their internal teams, especially by connecting the technology transfer and research teams, and this involvement is essential if the innovation initiatives are to make a more assertive and clear contribution to the Unit's agenda.

Today, Embrapa units carry out various types of innovation initiatives, including pitches, hackathons, open innovation calls, mentoring, startup acceleration processes and partnerships to promote connections, among others. It was possible to observe that this variety is related to the diversity and particularity of each Embrapa unit, as well as the objectives that gave rise to the initiatives.

In general, the initiatives have little involvement from other Embrapa units in their construction and implementation. Although, in the majority of cases, this was not seen as an effective choice on the part of the Units, it was clear that, most of the time, they didn't even take this option into consideration, given the company's culture of isolated and still competitive work between Units. Although progress is being made to reverse this reality, this dynamic still occurs and is present beyond innovation initiatives.

The Units are eager for guidelines and instruments to help them build innovation initiatives and programs, which has shown the relevance and importance of this work as a contribution to institutionalizing this process. In addition to providing guidance to help institutionalize the process of building open innovation initiatives, it is hoped that this work will encourage new initiatives to be carried out more effectively and efficiently, as well as contributing to organizational learning. It is also hoped that the solution proposed here will actually be implemented and used by Embrapa's decentralized units.

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