RESEARCH ARTICLE OPEN ACCESS

Technological Forecasting: Methodology Embrapa Brazilian Company

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ABSTRACT
Structural, economic and social changes are present in organizations. One of the strategies for decision-making, which leads to organizational policies, is the construction of feasible and doable technological scenarios that enable innovations to trigger the processes of technological change. This study to analyze the prospect of technological scenarios in the Brazilian Agricultural Research Agency a public organization of Research, Development and Innovation, based on scenario building in its operating environment. For the methodological procedures, a systemic review addressing the problem of searching for qualitative bias was developed. Taking this study's point of view, the research is exploratory and descriptive. The sources of data collection were primary and secondary. The technical consistency of prospective scenarios for the company was highlighted in the results of this study, as this was the object of this analysis. Through the collected data it was possible to verify the inferences between literature and the applied method. [JEL Classification: O310].
Keywords **-** Innovation and Invention Processes, Prospective Scenarios, Technology.

I. INTRODUCTION

The scenarios methodology is in one of the most effective techniques to prospect the future and operationalize the actions dealing with uncertainties. In this sense, it should be noted that it is not the same as shaping the future the future, but rather, it is systematizing actions, defining uncertainties and experiencing changes [1].

The multiple-scenario technique is a tool based on the premise that one can not predict the future, but speculate about many futures and thus open up the mind to see a better, more consistent future. Under the analysis of an economic perspective, when it comes to competitive strategy, the scenarios should be adapted to a business reality taking into account the strategic forces of competitors [2, 3].

The value in scenario building relies on the awareness of managers to open up possibilities that would unlikely be perceived otherwise. Therefore, the scenarios collaborate in organizational decision-making processes in terms of better timing, thus reducing the chances of unwanted surprises during the process [4]. In this sense, the popularization of the scenario building technique, as a way to strategically manage organizations, was the initiative of the prospective business created by Peter Schwartz and Pierre Wack [5].

In this approach, the present study aims to develop an analysis in order to answer the question problem that guides this research: how does the prospect of future scenarios happen in a research, development, and technological innovation Brazilian company?

Thus, the following research objectives were proposed:

General Objective: To analyze the prospect of technological scenarios in the Brazilian Agricultural Research Agency EMBRAPA, a public organization of Research, Development and Innovation (RD&I), based on scenario building in its operating environment, in the period of 2002-2012.

Specific Objectives:

- Identify the operationalization of the technique.
- Identify the results considering the physical, human and financial resources.
- Identify the required time to obtain the result.
- Describe the complexity of the technique.
- Assess the reliability of the results.

Therefore, this research is a case study and the object of study is the Brazilian Agricultural Research Agency EMBRAPA, a public organization of Research, Development and Innovation (RD&I), based on scenario building in its operating environment, from 2002 - 2012.

This paper is organized as follows: section 2 deals with the general and conceptual approach concerning technological prospecting scenarios using the multiple-scenario technique; section 3 deals with the applied methodology; section 4 presents the results; section 5 presents data discussions; section 6 presents the conclusions of the research in line with the general and specific objectives and, finally, the references used in the study.

II. PROSPECTIVE SCENARIOS

In terms of the analysis of the consistency of the technical prospective scenarios for a Brazilian research firm the study is based on the assertion that the operationalization of the technique of prospective scenarios should be done in a simplified way, as the results of this work should be understood and applied with ease by organizations, in order to contribute with the building of the future, taking into account the strategic actions of the present [5, 6].

When it comes to identifying how the multiple-scenario technique is applied it is necessary to identify how a "good" scenario may be defined. This way, a scenario that is considered good explains not only a future situation but also how the alternatives that may arise might collaborate in the formulation of public or private policies, in order to prevent, avoid, minimize, redirect or redefine strategic routes. Therefore, scenarios' surveys collaborate with organizations, whether government, business or social interests, in visualizing future actions even if in different conditions, in relation to both internal and external environments [1].

Motomura [4] considers that good scenarios are affected by the way managers think and how the future can be molded and shaped, just as it allows insights in the reduction of risks or odds for decision making. In addition, the scenarios operationalize the elements of a larger system and its interactions with the environment, with clear descriptions of the future.

In this context, the main scenario techniques are: scenarios with consistency checks and scenario management; simulation scenarios through gaming and interactive scenarios; the technique named Field Anomaly Relaxation Method – FAR [7, cited in Coates et al, 2001].

Hence, it is considered as scenario management the proposals of actions for different future technology concepts, whose characteristics are based on a defined set of assumptions and conditions, for which the forecaster should evaluate the validity. The results of this assessment are used to identify the most likely scenario to occur. It is worth pointing out that, in this context, the FAR technique, whose objective aims to provide a range of possible scenarios and plausible to be achieved, by means of a historical scenarios and a final result, forming the basis for policy formulation as well as decision-making initiatives [7, cited Levary and Han, 1995].

Regarding the results of these multi-scenario techniques, given the financial resources, in other words, the cost of operation, it can be inferred that few organizations are willing to bear this cost. One of the analyzed items refers to the significant cost in relation to expenses with the team involved, bringing, on the other hand, benefits to be derived. What stands out is that some managers evaluate the scenarios discussed in relation to strategies and results available in the long term [8]. In this respect Motomura [4] considers the technique has incalculable value regarding benefits, keeping in mind the fact that it is possible to monitor the very future of the organization.

Another important factor refers to the required time to obtain the result, since the study of scenarios may vary depending on the dynamics and evolution of the system being studied. It is considered, therefore, an average of ten years and it is recommended that scenarios are developed with greater time horizon than five years, as the main objective of the scenarios is to assist in defining the company's strategies, and these guidelines require a long-term approach. It is noteworthy that the horizon of scenario creation does not depend solely on the nature of the industry, but it also relates to the theme object of preparing the scenario [9]. When defining the length of time, one should take into account the time horizon of the strategic decisions of the organization's investments [2]. Take, for example, the FAR cycle, which involves approximately twenty weeks of work and should be carried out in four steps. A second cycle may be performed in a shorter time, which, depending on available resources, may take longer to deepen the strategies addressed in the first cycle [8].

A further aspect to be considered is the complexity of the techniques to be adopted and, in this respect, it is valid to observe that scenarios are complex systems, as they seek to reveal early signs of future changes [4]. This way, multiple-scenario analysis can be considered complex as it is a tool that adopts a qualitative methodology (subjective analysis) to help in the action of a long-term vision, therefore, resting on the practice of strategic conversation, having in its surroundings a world of political, social, economic and technological uncertainties [10]. On the other hand, the multiple-scenario technique can be considered flexible and simplified as it allows planners to develop policies in the present to prevent that in the future they reach the conclusion that decisions had not been successful [11].

The reliability of the results relies on statement that prospective studies are not intended to predict the future, but rather to study the various future plausible possibilities and, thus, prepare organizations to face any of the listed outcomes, creating conditions for modifying the probabilities of occurrence or even minimize their effects [6].

Under the strategy structuring approach are the strengths and weaknesses in the operationalization of the multiple-scenario technique. Strengths presented are: a complex portrayal of possible futures; incorporation of various pieces of qualitative and quantitative information produced by prospecting methods and also, they may incorporate elements that enable decision-makers to define strategic actions. In terms of weaknesses, it is worth mentioning that sometimes the prospected scenario may have an illusionary aspect of fantasy, as when a desired future is identified, the constraints and barriers that may be encountered during the process of realization of such results are often not considered [12].

III. METHODOLOGY

The methodology used in this study corresponds to an exploratory and descriptive study with a transversal snip. As for the technical procedures, a documentary research was developed. The source of data collection is considered both primary and secondary. Secondary data were collected in technical and scientific articles, reports, and mainly in the document "Pesquisa, Desenvolvimento e Inovação para o Agronegócio Brasileiro - Cenários 2002 – 2012" ("Research, Development and Innovation for the Brazilian Agribusiness – Scenarios 2002 – 2012") [13]. To collect primary data, semi-structured interviews were conducted with 3 Embrapa managers, who were part of the preparation of the above cited document. The analysis procedure is predominantly a qualitative approach.

The chosen method for this paper was the case study method, which according to Yin [14] is a research strategy that includes a comprehensive method with specific approaches to collecting and analyzing data.

In this study the relevant research questions were listed. These were part of the questionings, in order to perform checking and analysis of the consistency of the prospective technological multi-scenario technique for the company, object of this study:

- How was the prospective technological multi-scenario technique applied?
- How can the results be evaluated, given the available resources?
- What is the necessary time to achieve the result?
- What is the complexity of the technique?
- What is the reliability of the results?

Through data collection and analysis it was identified that results met the necessary measures to achieve the objective of the research, by the inferences proposed in the literature.

IV. RESULT

Earlier in this section, Embrapa, the object of this study, is presented, as well as its operational structure as a technology-based company that conducts RD&I having as a fundamental guideline the building of technological scenarios for exploring future actions and also implementing actions in the present. Next, surveys extracted from the primary and secondary data are presented. This way, it is possible to check the consistency of the prospective multi-scenario technique for the company.

4.1 Brazilian Agricultural Research Agency

The Brazilian Agricultural Research Agency (Embrapa) is a public organization of Development, Research and Innovation (RD&I) established in April 26, 1973, and is linked to the Ministry of Agriculture, Livestock and Food & Supply. Since its establishment Embrapa has made it its challenge to develop, along with partners from the National Agricultural Research System (NARS), a model of tropical agriculture and livestock typically Brazilian, with the goal of overcoming the barriers that imposed limits on the production of food, fiber and energy in Brazil.

Embrapa, today, has 17 core units located in Brasília - DF; 46 decentralized units in all regions of Brazil; 4 virtual laboratories abroad (Labex) in the United States, Europe, China and South Korea, and 3 international offices in Latin America and Africa. The workforce of Embrapa is comprised of 9,790 people, of which: 2,444 are researchers, of which 84% are doctors; 2,503 are analysts; 1.780 are technicians; 3,063 are assistants.

Embrapa is a research, development and innovation company that aims at the promotion of new knowledge, largely represented by products, processes and services for the Brazilian agricultural sector. It presents actions and qualified information to increase industry competitiveness and sustainability. The company's main objective is to strengthen the ability to respond to the demands of the agricultural market and, at the same time, anticipate and meet the challenges of the future. With its focus on innovation, it searches, through building scenarios, for solutions that will contribute to the growth of the agricultural sector anticipating actions for the projected years.

4.2 Operationalization of the technological prospective multi-scenario technique

To implement the technique other techniques were used in conjunction with the prospective technological scenario study, because according to what one of the managers said in an interview, no prospective technique dispenses the views of the stakeholders, that is, of the futures market experts, or projections involving econometric models, among other methods.

According to documents in the prospective analysis, for the previous study of scenarios, three questions referred to as extrapolative, exploratory and normative were designed. In the extrapolative dimension, it is considered that the future is the extrapolation of the past with deterministic nature. In the exploratory dimension, it is considered that the future has alternative possibilities of evolution given by the forces of the present combined with those of the past, exploring complexity. In the normative dimension, it is considered that the future can be built depending on social values. In the utilization of such process of analysis all dimensions must be combined and given proper emphasis, which depends on the proposed objectives and availability of data series, besides taking into account the time horizon.

In the construction of the technique, according to a respondent, the types of considered scenarios were: trendy, this is what tends to happen, which considers the development of the future is based on projections of historical trends; exploratory, what may happen, which considers the possibility of alternative futures, and, furthermore, the normative scenario, which considers what should happen with the potentialities that are expected. For such, three periods were designated. The first reflected a presentation of a researcher with vast experience in the subject under debate. Questions were made by a team of experts. Finally, each professional of the group presented their consideration and scientific position on the issue. The choice was made by a simple majority of participants in each group.

The scenarios were prospected by morphological investigation matrix used to construct the Scenarios A, B, C and D, on the basis of the survey of the critical uncertainties and assumptions regarding the alternative states of the uncertainties in the period 2002-2012. This matrix illustrates all sectors and phenomena that affect critical areas of performance of the company. Also, it shows a survey, in full, of all the nuances and specifics that may occur in different scenarios. It was highlighted by respondents that all possible inferences of variables that could impact in the areas of operations of the company were exhausted, always focusing on research, development and innovation, both nationally and internationally.

4.3 Identification of results given available resources

The identification of results in relation to the resources that were available, according to data from the interviews, depended on each topic discussed. The amount of capital required for the development of the technique was not informed by the respondents, who claimed ignorance regarding the actual funds made available. One of the respondents said that spending in general involved travel, equipment such as a projector and computers, teaching materials, among others. However, what everyone stressed was that the most important scarce resource is researchers and, accordingly, they were considered, according to one interviewee as "effectively resources of the highest value".

Respondents reported that the expert advice of Macroplan company was hired to conduct the work. The consulting firm presented as a guideline of their work, a specialized methodology, an approach in stages, according to Fig. 1, namely: define the scope and purpose; identify the determinants of the future; generate and choose the scenarios; develop at least three scenarios; compare and analyze prospected scenarios, being that all these steps result in planning and strategy management, and, finally, encompassing all the previous steps, develop and operate an information and monitoring prospecting system.

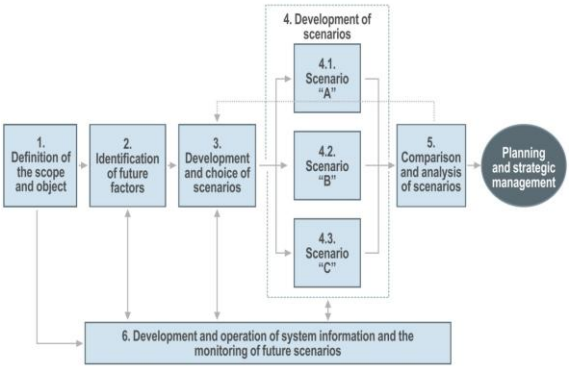

Figure 1. Macroplan Methodology
Source: [14]

With regard to the expert consulting advice, one respondent stated that, in his opinion, the consulting service only served to aid in the moderation of the proposals during the event because the study was well conducted by the internal team of Embrapa. Respondents stated that the participants were members of the Internal Technical Committee (Comitê Técnico Interno - CTI) of each unit. Around 200 professionals were involved, however, there was a concentrated team making up

the decider core, with over 20 names.

They also state that, at Embrapa, each topic covered in a prospective study involves multidisciplinary teams, most of which specialize in particular topics. They mentioned that the choice of those involved is made by suggestion of the CTI, with the participation of the Head of Research and Development. The profile of those involved is described as everyone having master level and / or doctorate education with many having published studies. They are professionals of national and international reputation for the most part. They form an elite group of research in the area. Finally, according to the respondents, although many are involved in the elaboration of scenarios, decisions are of made collectively, as a committee.

4.4 Identification of the time required to obtain the result

According to one respondent, in the initial stage, meetings were held for the operationalization of the technique. Other managers corroborated this. It took around two days of organizing, debates, analyzes and suggestions of work around the issue. The scenarios were developed with a 10-20 year horizon. Therefore, reevaluations of the projections were made for shorter periods than the final horizon. One respondent pointed out that each and every research has its specific analysis, and when unusual issues arise and proposals to address them come up, they are immediately implemented, during the scenario planning process.

4.5 Describing the complexity of the prospective multi-scenario technique

According to secondary data collected, when considering the complexity of the multi-scenario technique critical factors arise, such as any variables that may, positively or negatively, affect the performance of prospected system. When it comes to the driving force, it is considered such any phenomenon that leads the behavior of a critical factor in a positive way, or acts as restraining force. In this respect, according to one interviewee, all complexity correlates with the discussed theme.

Per findings in the secondary data, the technique allowed the establishment of assumptions regarding prospected scenarios for Embrapa, involving the complexity of the technique and its scope, such as: change of the political support base of the company; the need to create new partnerships strengthening links with universities, research centers, stakeholders, and others; integration of new scientific paradigms through traditional techniques; training for the development of skills to resolve agro-ecological problems; training to defend broader interests of society, in view of the trend of technology privatization.

Through primary data from interviews, it can be noted that while the technique is complex it can also be considered as flexible as it collaborated in the developing of the strategic tactical planning, whose time is shorter and foresees practical actions, such as threats and opportunities, in the daily routine of the company.

4.6 Evaluating the reliability of the results

One respondent stated that "in each and every researcher there is balance, rationality, common sense, because when we make mistakes, we're sure of it, and when we hit it, we're not sure we did it". This explains the limitation of scenario development in relation to the prospected results because this science is not driven by the number of successes, but it is driven by paths that lead to a reduced number of errors.

In this sense, scenario generating processes were tracked while all data and information were monitored, resulting in that all discussion materials were made in the form of filed documents for the preservation of the decisions and strategies adopted by the company.

In terms of weaknesses and strengths of the multi-scenario technique, strengths are those that guide the main strategies; the potential effects of phenomena arising from the external environment; the flexibility of the plans that are the result of future uncertainties; the incorporation of different points of view; stimulation and monitoring of important trends and events, giving subsidies for the decision maker to prepare the present with a view to the future. The weaknesses were highlighted as the identification of all situations where the certainty of progress is not considered strong enough to drive action. In this sense, there is often lack of professionals that deepen themes of secondary order that in time can become a priority; scenario planning involves the guidance and participation of experts; need for information in non-conventional ways and also interpretation of scenarios is not considered traditional.

V. DISCUSSION

The data collection method for this study combined the use of primary and secondary data, following the recommendation of Yin [14], as for this research multiple sources of information were accessed.

Primary data collected in the field research were obtained through interviews with managers. Secondary data were extracted from the publications on the website of the company, object of this study, and also used as the main source the document the Embrapa Prospective Scenarios 2002 - 2012.

Initially data regarding company identification, its area of operation and coverage in national and international scene were collected.

After that, the key people to be interviewed were identified, being that the participation of managers who had worked in the preparation and implementation of the actions for the document of prospective scenarios in the considered period.

Then, the script for carrying out semi-structured interviews was prepared. Thus, three interviews were conducted with managers and data were later collected, published in a period of 10 years, which allowed the triangulation and the promotion of the time perspective. This way, the information gathered were corroborated in the light of the base theory described in the theoretical framework.

Finally, the considerations regarding the results and impacts in the construction of scenarios through the preparation of a document describing the methodology and its application for Embrapa in their technological processes for the establishment of their mission and institutional goals set based environment external. Other objectives have been achieved by providing the decentralization of decisions at all levels of Embrapa. Another highlight was the training of human resources at Embrapa regarding methodologies and techniques of strategic planning, creating subsidies to the formulation of master plans of Embrapa. According to data from Embrapa [16] the basic question for technological forecasting is the assessment of needs for the agricultural business in the period of 2002-2012. Therefore, it is emphasized that it is essential to anticipate future situations as well as their technological requirements to effectively plan RD&I actions.

Within the prospective analysis, it has been taken as a basic principle the emphasis on understanding the future to change the current situation, considering the conception that this is the result of interactions between historical trends and hypothetical events. As a purpose of the method, the analysis of the influence of the present on the alternative future as well as the impacts on future policies and strategies are highlighted. Other points to be noted were the purposes of the scenarios that were highlighted, such as: the company's preparation for the uncertainties of the future; the possibility to set goals for decision-making, formulating objectives, guidelines and alternative institutional strategies; identifying threats and opportunities from changes and, last but not least, the support in the preparation of the strategic plan of the company.

Other significant results were the expansion of operations of Embrapa; the awareness of the need for greater integration of the company with society; the motivation for the development of a strategic posture, as well as guidelines for the development of tactical and functional planning, according to interviewees.

Therefore, the construction of scenarios in relation to the methods of analysis can be considered: intuitive logical analysis, not using a mathematical algorithm; impact trend analysis based on classical prediction techniques, by means of econometric models; cross impact analysis based on the assumption of the existence of interrelationships of future events [16].

VI. CONCLUSIONS

The general objective of this research was to analyze the prospecting of technological scenarios at Embrapa, checking, in this analysis, the consistency of the technique through empirical study. Therefore, the data collected allowed to corroborate the theory around the theme because it was possible to analyze how the scenario planning process was, as well as the strategic inferences from the prospecting of the technological scenarios for Embrapa.

In the first specific goal, in the identification of the operation of technique, it can be seen that Embrapa used the scenario application for the purpose of formulating policies, objectives and guidelines for the organization, defining strategic routes in proposing actions to be taken. Interviewed managers pointed out that the technique allowed insights that have led to the reduction of risks and allowed successful decision making through the four possible scenarios shown to be achievable.

Regarding the second objective, in the identification of the results given the resources available, it was found that the cost was represented by the hiring of the consulting firm, although the work was developed in conjunction with the team of researchers from the agribusiness sector area. Therefore, the cost was considered as low investment keeping in mind the assumed value of the technique, taking into account the strategic support documents generated in the study.

Concerning the third specific objective, considering the identification of the required time to obtain the result, it was concluded that the time was a crucial factor because the scenarios were built for a time horizon of 20 years, and although the forecasted scenarios were monitored and reviewed in shorter periods, as proposed by the literature experts.

For the fourth specific purpose, in the description of the complexity of the technique, it was found that it may be considered complex when taking into account the long-term planning, besides the objectives to be reached, which can be considered flexible and often erratic because they deal with uncertainties for the future. On the other hand, the technique can be considered simple in the sense that it also allowed strategic planning, given the threats and opportunities for a short period of

time, for more specific actions of the company, which can be corroborated by theory.

Regarding the fifth specific objective, in assessing the reliability of the results, it was observed that, according to theory, the construction of scenarios was not intended to predict the future, but rather, to explore the possibility of plausible futures and for that the company is supported by previous study of scenario mapping, anticipating situations with the possibility of modifying or minimizing occurrences that may be negative for the company in its field.

Finally, the study showed the consistency of prospective multi-scenario technique for the company, object of this study, and through the data collection it allowed the verification of inferences between the proposal from the literature theory and practice through the applied method. The limitations of this study lie on its generalizations, as the study presents the reality of only one company. However, it is suggested for future studies that this research is replicated as a contribution to other technology companies, leading to the review and consolidation of surveys of technological scenarios in their innovation environments.

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