Analysis of the process of technology transfer in public research institutions

The Embrapa agrobiology case

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Abstract

Purpose – Empresa Brasileira de Pesquisa Agropecuária (Embrapa, the Brazilian Agricultural Research Corporation), owned by the Brazilian Government, is one of the most efficient agencies for promoting sustainable tropical agriculture in the world. However, although information is available, farmers do not always put the technologies and knowledge into practice. There is a large difference between the average productivity of farmers and crop or herd potential. Thus, this paper aims to describe and analyze the process of technology transfer of the Embrapa Agrobiology Unit.

Design/methodology/approach – The study reviewed the classical and diffusionist models of technology transfer (TT) in Brazilian agriculture and the role of the government in innovation. This was based on documentary research and structured interviews with four employees, supported by a structured roadmap composed of four categories for analysis: the role of TT; the organizational structure of the area; the TT strategies; and the ways of delivery, methods and tools of TT. By a qualitative approach, the results were treated through content analysis.

Findings – The results indicated that the area of TT at Embrapa went through a recent restructuring, which included the interchange and collective construction of knowledge (ICC) in its TT process, to turn entrepreneurship into reality. The company is dedicated to bringing knowledge to the most important people: farmers. This has been done through a participatory TT model, which has involved multiplier agents from the research stage to the transfer stage.

Research limitations/implications – Some limitations were found, among them, the fact that only internal members of Embrapa were interviewed, limiting the view of the TTICC staff and without knowing the multiplier agents' opinion and other actors involved in the process. In addition, it is a qualitative research that is subject to the interpretation of the researcher.

Practical implications – This study contributed to reflections about the TT process and how it can be used by different actors, along with the role of the State in innovation.

Social implications – In addition to contributing to the development of products, processes and technologies for the economic, social and environmental development of Brazil, Embrapa has been outstanding in generating knowledge for the advancement of science. Its results have had impacts not only

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nationally but also worldwide. Embrapa has played a key role in Brazilian agriculture as well as in livestock, mainly, in supporting governmental projects and in the implementation of public policies.

Originality/value – The aim of this study was achieved, as there was a possibility of describing and analyzing the technology transfer process at Embrapa Agrobiology Unit, located in the city of Seropédica, Rio de Janeiro. It is concluded that Embrapa has been committed to involving the farmer in the process of interchange, collective construction of knowledge and technology transfer. The farmer has become the focus of this process, reducing the development of "shelf" researches and increasing the participation of the farmer or of the multiplier agent. The importance of studying and knowing the process of technology and knowledge transfer to the public of interest should be highlighted, and especially the reasons why this technology or knowledge are often not adopted by the public. It was possible to identify that Embrapa has noticed the difficulties of farmers and realized that the best way the best way of transforming technological solutions and knowledge into innovation is by involving the farmer in the process of construction and of transfer. Thus, the farmer gives greater credibility to the technology or generated knowledge because this is something that he himself helped build. In the sphere of contemporary institutional knowledge management, Embrapa has had as its main point of departure the demand and the needs of society. For this, it has created means to ensure the participation of different actors because they signal the construction of technological solutions and of innovation and they are the ones who know the real situation. However, this is a recent progress within Embrapa that has evolved and generated results. Thus, research, science and technology institutions must go beyond technology transfer and must ensure the involvement, participation and interaction of the public of interest to promote significant change, social, economic and environmental development and transformation. Embrapa observed this from the referential framework that included technology transfer, interchange and the collective construction of knowledge.

Keywords Innovation, Technology transfer, Brazilian agriculture

Paper type Research paper

1. Introduction

The transfer of knowledge and technology is a process that includes players from private and public organizations (Horne & Dutot, 2017). Through resources, almost exclusively from the government, public research institutions (PRIs) have the role of creating and disseminating scientific and technological knowledge, so that it can be incorporated into the daily lives of people. However, the efficient diffusion and the transfer of technology to the intended audience are a major challenge for these institutions (Bassi, Silva, Schneider, & Carvalho, 2014).

In the agricultural sector, there is a difference between the average productivity obtained from producers and the potential of crops. Although there is technological information available to increase productivity, not all producers have access to it or, in other cases, do not adopt it. This is a problem of technology transfer and knowledge exchange. One of the reasons may be the failure in prospecting demand for technology, a problem that precedes the transfer process itself. There may be an imbalance between the development of technology and the real needs of its potential users (Fujisaka, 1994). In addition to the difficulties of demand prospecting and technology transfer, it is necessary to demystify the idea that the use of technology requires high investments and capital contribution (Oliveira, 2012). The transfer of technology involves a set of actions that seek to incorporate instrumental resources to increase production and productivity, generating economic, social and environmental impacts (Dereti, 2009). In a more contemporary approach, the transfer of knowledge is a critical factor to the advancement of productivity (Janis, 2003). It is the transfer that guarantees the applicability of the technologies generated (Embrapa, 2016). At this stage, technologies are expected to be easily adopted, which is not always the case for various reasons. We conclude that the technology transfer process needs to be analyzed and understood. Thus, the research problem can be summarized in the following question: How does the process of technology transfer occur in the case of Embrapa?

The Agrobiology Unit of Embrapa has directed efforts to TT, based on the adoption of more contemporary theories and models of TT. For this reason, this unit was investigated. Thus, the main goal of this study was to analyze how the process of technology transfer occurs in the Agrobiology Unit of Embrapa. More specifically, we analyzed:

- the role of the TT area;
- the structure of the TT area;
- the strategies, delivery routes, methods and tools of TT; and
- the role of the government in fostering innovation through Embrapa.

To achieve this research goal, we used a qualitative and descriptive research method based on the analysis of a single case study.

This article contributes to new insights about the process of technology transfer, including knowledge exchange, which is an innovative element in this process. Although this study was applied to the agricultural sector, its results can be used to improve the TT process in different sectors. The article discusses how different players can work together to achieve more effective results in TT, including the government, through research institutions such as Embrapa, and the various farmers and agents. The contributions of this article also highlight the importance of the involvement of farmers in the TT process to ensure its effectiveness.

The results indicate that the process of technology transfer and knowledge exchange, in the case analyzed, involves the main protagonists of this process – farmers. The participation of the farmers or multiplier agents brings greater credibility to innovation by virtue of the collective construction of knowledge, enabling the more effective transfer of technology. The multiplier agents are farmers who participate in a training process with Embrapa and, in addition to bringing the demands of other farmers; they are challenged to pass the information learned in training to other farmers. Next, the theoretical framework of the study is presented, which includes the analysis of the agricultural sector, the role of the government and the transfer of technology.

2. Literature and theoretical framework

2.1 The agricultural sector in Brazil and the role of the government

The government plays an important role in the food industry, which goes beyond being a regulator to ensure food security. On the one hand, in some countries, like the United States, the government has protected the food industry from foreign competition through trade measures like direct financial support – a.k.a direct subsidies – and the reduction of tariffs for domestic farmers (Dicken, 2011). On the other hand, the government has played an important role in the technological development and in encouraging innovation through PRIs. The consistent long-term public investment has been crucial for innovation in modern society (Mazzucato, 2014); this applies to private as well as public companies.

In the case of Brazil, in the 1950s, the state fostered a development policy based on industrialization, from external capital funds. Since the beginning of the twentieth century, the Brazilian Government sought to structure the areas of agriculture, industry and biomedicine. In this context, the Brazilian Oil and Gas Company (Petrobras), the Aerospace Technical Center (CTA) and the National Institute for Space Research (INPE) were created. In 1973, according to the view that the government should lead innovation policies in the country, the Brazilian Agricultural Research Corporation (Empresa Brasileira de Pesquisa Agropecuária – Embrapa) was created to strengthen the Brazilian agriculture.

Embrapa is a public research institution for technological innovation focused on the generation of knowledge and technology for Brazilian farming and stockbreeding. It is recognized worldwide for its agriculture model as well as for the promotion of tropical farming and stock raising, having one of the most efficient and sustainable models in the world (Embrapa, 2016). This has contributed to Brazil's position in the world's largest producers and exporters of food (OECD - Organization for Economic Cooperation and Development, 2015), along with the USA and China (Dicken, 2011).

Historically, agriculture in Brazil has had great importance in the foundations of the economy. There is a diversity of small and medium producers and traditional communities in all regions of the country that stand out for the economic and social subsistence. Production from family agriculture represents a considerable part of Brazilian agribusiness (IBGE - Instituto Brasileiro de Geografia e Estatística, 2006). More importantly, the Brazilian economy has always relied on large farming enterprises, starting with sugar, then coffee, and more recently citrus, soybeans, beef and poultry, all of which are current mainstays of the economy.

Through partnerships between the private sector and the government, represented by Embrapa and the National Agricultural Research System (SNPA), the agricultural sector has strengthened and contributed to the social, economic and environmental development of the country (Carli, 2005). In this case, the role of the private sector is to develop new products, such as seeds, fertilizers and machinery, while the role of the government is to raise the essential knowledge for the improvement of production, e.g. the proper way to apply supplies, the best spacing of crops, the mapping of risks and best practices to overcome them, among others (Embrapa, 2014).

The government plays an important role in this process, especially in Brazil where agriculture plays a strong role in the country's economy. The economic growth of countries around the world needs to be driven by innovation, which requires the government to implement policies and make investments (Mazzucato, 2014). This is an idea that goes beyond the traditional role of regulating or intervening in the market; it is about encouraging both private companies and public research institutions to engage in innovation.

2.2 Technology transfer

Technologies are nothing more than tools and machines that solve problems or make solutions simpler without necessarily requiring expensive resources. Diffusion is the process by which innovation is spread by certain means or channels to members of a social system, with the aim of reducing the time between the generation and the adoption of technology (Rogers, 1962). The communication refers to any message exchanged between two parties, while transfer relates to innovation exclusively, and the knowledge being conveyed may or may not be accepted by the potential users (Rogers & Shoemaker, 1974). This article is limited to the analysis of the technology transfer process.

Since the 1960s, studies have attempted to define the concept of technology (Galbraith, 1967; Skolimowski, 1966). The concept of technology is associated with what is being transferred in a process of technology transfer (Bassi et al., 2014). It can be scientific knowledge or another kind of knowledge, as long as it is organized and has practical applications (Galbraith, 1967). For Skolimowski (1966), technology is associated with a process of creating new realities. Technology transfer is associated not only with a tangible product, but also with the knowledge that is generated and how it is applied (Bozeman, 2000). Herein, we consider that technology and knowledge are intrinsically interconnected.

All technology needs to be transferred through a process that goes from its developer to the users. However, there are many problems in this transfer process, one of which is the reluctance to adopt the technology by potential users. This can occur due to an inadequate transfer or to a technology development process independent from the user (Fujisaka, 1994). Another problem is the acceptance of technology based on the evaluation of the potential user. It is important to be aware that adoption occurs in a social context that has local characteristics, an aspect that should be taken into consideration from the development until the transfer of technology (Johnson, Gatz & Hicks, 1997).

Under the more traditional approach of TT, it is possible to affirm that there is little or no participation of the target audience in the process of building technology. This makes it difficult to adopt technology, either due to the lack of credibility (Johnson et al., 1997) or because the technology does not meet the real needs of users. Fujisaka (1994) argued that often a technology is not adopted either because it is inferior or equivalent to the current practice of the user, or it does not match reality, or has not been transferred to the target audience in an appropriate way. Research itself is not sufficient to meet the real needs of users. An adequate transfer of the results of any investigation is necessary to guarantee that the end users adopt the new technology or the knowledge generated (Sulaiman, 2002). There is a lot of criticism in the literature about this transfer process, putting into discussion the poor implementation of these technologies and the use of technological packages (Acoba, 2001).

In the classic model of extension of the Brazilian agriculture, technology transfer is accomplished through an extension agent. This agent is the link between the research center and farmers through a unilateral process. This is the same model, originated in the USA, which lasted in underdeveloped countries of Latin America for many years, not only in Brazil. The purpose of this model, developed by Rogers (1962), was to bring to producers new ways to increase productivity through methods and tools. However, this occurred through a process of persuading and convincing farmers to adopt technology through five steps (awareness, interest, evaluation, judgment and adoption) proposed by Rogers (1962).

In this model, the Technical Assistance and Rural Extension Agents (TAREA) had the role of transferring the techniques and knowledge and for this; the techniques and knowledge were strategically organized to facilitate the transfer (Wagner, 2011). The diffusionist model (Rogers, 1962) is based on a linear process composed of three fundamental stages: generation and validation, technology transfer and technology adoption. The technology is developed for the farmers and other interested actors. The technology or technological packages are then developed in the company and transferred to the user, and at the end, the adoption of the technology is expected to result in higher productivity or economic gains.

The classic and diffusionist models of TT began to be questioned in the 1980s. This led to the development of several new models focused on the interplay of technological, institutional, social, economic and environmental aspects (Embrapa, 2014). This model presupposed a participatory, interactive and interdisciplinary approach. The different perspectives contributed to the already developed knowledge and technologies being interpreted and adapted, considering the social context.

Several factors involved in the transfer process have received more attention (Howells, 2006). Another approach given in the literature about TT is the collective construction of knowledge. Gibbons et al. (1994) proposed a new way to produce knowledge (new production of knowledge). This proposal considers, regarding the process of knowledge construction, the social context in which it will be applied. This model focuses on the participation of farmers and other partners rather than the development of technological

packages for potential beneficiaries. The model of collective construction of knowledge for TT in Brazil includes universities, TAREAs, farmers, market players, government agencies, NGOs, suppliers of inputs and Embrapa.

The different actors considered must be involved in the process of knowledge construction, since all perspectives are addressed, as well as the social context of knowledge application. In this model, as advocated by Gibbons et al. (1994), dialog and interaction are the key elements. Thus, it ceases being a linear model of production of knowledge and technology. For Heberlê, Cosenza, and Soares (2012), this practice of collective construction of knowledge is more effective than formal contacts or exchange mediated by technical devices of any nature, for example TV, internet or publications.

However, in practice, the diffusionist model of TT still prevails. However, the diffusionist model of TT is the most used. Despite the models that consider more the user's real need and less the market supply (technological packages) have advanced, the reductionist view prevails focused only on the dissemination of research results (Schlottfeldt, 1991).There is also the helical model of Heberlê et al. (2012), which considers a sequence of cycles articulated by science and society (Figure 1). According to the author, the model can be divided into four stages: planning and prospection; validation and execution; impact interaction; and evaluation. This study focused on the execution stage. In it, the cycles represent the continuity of the phenomena and the information feedback, as it occurs in agricultural research. In this proposal, social interaction and research cannot be separated (Embrapa, 2014).

Embrapa has adopted a model of technology transfer and exchange of knowledge closer to contemporary models, such as the helical model of Heberlê et al. (2012), than the classic and diffusionist models. Therefore, this article analyzes TT models that focus on the participation of different players and the collective construction of knowledge.

To identify the theoretical framework (Figure 2), we used two fundamental elements that support this study: the transfer of technology and the exchange of knowledge, both in the context of the agricultural sector. First, an effective process of TT is the central element of this article. Second, based on more contemporary approaches, the exchange of knowledge is an innovative element in the TT process to ensure its implementation. However, the exchange of knowledge is possible only with the participation of the various actors. Figure 2 presents our theoretical framework.

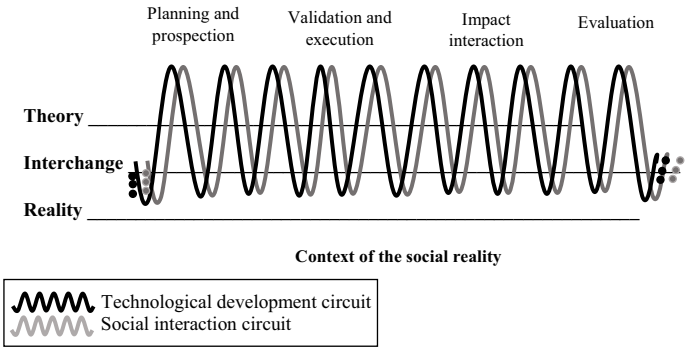


Figure 1.
Helical (or DNA) model of Heberlê

Source: Heberlê et al. (2012)

From this framework, we constructed an instrument to collect data based on four categories of analysis that correspond to the specific objectives of this study: role of TT; structure of the TT area; strategies, forms of delivery, methods and tools of TT; and the government's role regarding innovation in TT. In the next section, we describe the methodology.

3. Methodological procedures

A qualitative approach was adopted to analyze the problem. Qualitative research deals with interpretations of social reality, having as its main pillar in-depth interviews (Gaskell, 2002), as occurred in this study.

The analysis involved the process of technology transfer, interchange and collective construction of knowledge in the Embrapa Agrobiology Unit. The headquarters of Embrapa, located in the capital of Brazil (Brasília), is linked to the Ministry of Agriculture and Food Supply (MAPA). It develops, in conjunction with the National Agricultural Research System (SNPA), a genuine Brazilian model of tropical farming and livestock breeding, seeking to overcome barriers that limit the production of food, fibers and energy crops in Brazil. It is a technological innovation company focused on generating knowledge and technology for Brazilian farming and livestock breeding.

Embrapa operates throughout the country, and develops scientific cooperation programs (Labex) in North America, Europe and Asia, in addition to technical cooperation in Africa and South America. The Embrapa Agrobiology Unit is one of the 47 decentralized units of Embrapa. Embrapa has researchers of world renown in biological nitrogen fixation (FBN). The Unit has about 150 employees, including assistants, technicians, analysts and researchers, altogether employing more than 9,000 people. The Embrapa Agrobiology Unit produces a lot of knowledge and translates it into technologies, products and processes, and is a global benchmark in FBN studies.

We performed exploratory research at the headquarters of Embrapa, and continued this analysis by focusing on the Embrapa Agrobiology Unit, considering its history, characteristics, key activities and lines of study. In stage we adopted documental search procedures, including consultation of the social balance sheet for the year 2015, the Referential Mark and the Electronic Portal. The case study was adopted as a research strategy, from the perspective of Yin (2017), whose subject was the Embrapa Agrobiology Unit, located in the city of Seropédica in the state of Rio de Janeiro. The aspects examined in this study are described in Topic 3.1. The choice of a single case study is justified by the peculiarity of the TT process, as defined by Yin (2017).

Data were collected through structured interviews carried out from September to October 2016 with the head of technology transfer of the studied unit, a researcher and an analyst with the Technology Transfer Department (DTT) of Embrapa's headquarters. Each

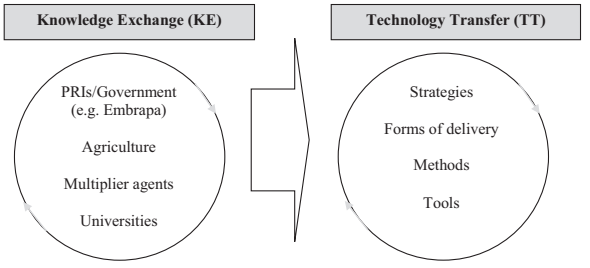


Figure 2. Theoretical framework KETT

interview had an average duration of 1 h. Subsequently, they were transcribed in full, resulting in a document of 30 pages. The interviews followed a structured script divided into groups of questions in four predefined categories, namely, the role of TT; the structure of the TT area; the TT process, which was subdivided into two sub-categories, namely, strategies and delivery means and methods and tools; and the role of the government.

By the nature of the data collected, qualitative treatment was used for the analysis (Bardin, 2011). The analysis of data relied on the following steps: pre-analysis (organization and systematization); exploration of data (coding, classification and categorization); and interpretation and judgment of the researcher. A summary of the methodological procedures used is presented in Table I.

4. Analysis and discussion of results

4.1 Reorganization of the technology transfer area

The area of technology transfer at Embrapa has gone through a restructuring process (Interviewee 2). This has contributed to many changes in how the technology is transferred. One of the impacts of these changes was on the organizational structure of the area. Nowadays, the Embrapa Agrobiology Unit is divided into three macro areas: Research and Development (R&D), Administration and Finance, and Technology Transfer Department (DTT). This article focuses on the DTT, which is divided into four coordinating sectors, namely: Sector for Prospection, Articulation and Evaluation of Technologies (SPAT), Sector for Implementation of Technology Transfer (SIPT), Local Committee on Intellectual Property Rights (CLPI); and Sector for Management of Integrated Agroecological Production Systems (SGSIPA). These sectors work together, without a very clear division among them in practice (Interviewees 1 and 3).

Stage	Method	Comments
Approach to the problem	Qualitative	Interpretation of the opinion of the interviewees
Type of research	Descriptive and exploratory	Descriptive (technology transfer and knowledge exchange process) Exploratory (Embrapa)
Procedure	Documental	March referential KETT Social balance 2015 Embrapa's electronic portal on the internet
	Single case study (Embrapa)	Embrapa's agrobiology unit
Data collection	Structured interviews with researchers in TT (use of structured script) = 4 Hours of Interview	Deputy head of technology transfer (Seropédica, RJ) Researcher in the KETT department (Brasilia) Analyst in the TT department (Brasilia)
Analysis of data	Transcription and Analysis of content (Bardin, 2011)	Categories of analysis: The role of KETT (specific objective 1); The structure of TT area (specific objective 2); Process: Strategies and forms of delivery technology and methods and tools (specific objective 3); The role of the government (specific objective 4)

Table I.
Summary of the methodological procedures

Source: Authors

Figure 3 presents the organizational structure of the technology transfer, construction and interchange of knowledge (TTICC) area of the Embrapa Agrobiology Unit. The SPAT is responsible for the evaluation of the technologies in *ex ante* studies, as in the prospective scenario, while technology is still being developed. The SIPT, in turn, is responsible for the evaluation of technology in ex-post studies, when it is already in contact with farmers in the experimental fields. In this case, the impact of technologies on society is evaluated. The SIPA is an exclusivity of the Embrapa Agrobiology Unit, as it is a management system for "Fazendinha Km 47", a self-sustaining model farm involving agroecological and organic farming. In each of these sectors, there are supervisors and researchers working together (Interviewee 1).

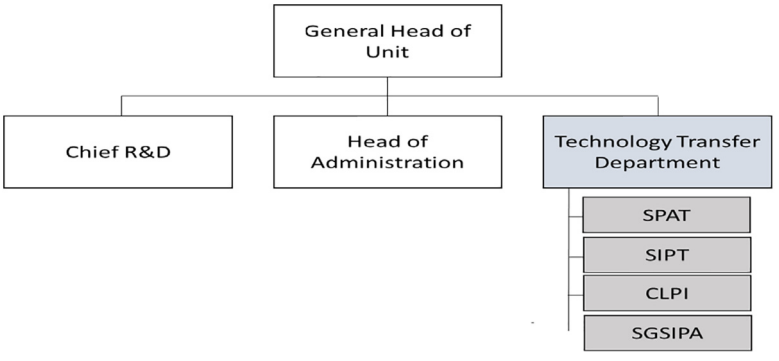
Since its creation, for many years Embrapa received support for technology transfer from the Technical Assistance and Rural Extension Company (Empresa de Assitência Técnica e Extensão Rural - EMTAREA), owned by the government of the Federal District of Brazil. Through this partnership, Embrapa had direct contact with farmers and producers for the transfer of technology. However, in 1990 this partnership ceased to exist, so for over 20 years, Embrapa has been an essential partner in TT. This caused many of its technologies to be on the "shelf", since they were developed without direct contact with farmers (Interviewee 2).

During this phase, Embrapa felt the need to develop technologies with the participation of farmers. For this reason, the Technology Transfer (TT) in the headquarters underwent a restructuring process which resulted in the creation of the department about seven years ago. Some units of Embrapa already worked according to the new restructuring, but only the management of TT officialized that specific framework (Interviewee 3). With the structuring of the area at the headquarters, this process has been disseminated to other Embrapa units.

4.2 The role of technology transfer: focus on the participation of producers

This new phase of TT has been marked by a search for dialog with farmers and multiplier agents, according to the model proposed by Rogers (1962). This was a milestone, involving Embrapa's relationship with society (Interviewee 2). Since then, the role of the transfer has been supported by three pillars:

(1) technology transfer (TT), which enables the generated results and products to reach the productive sector and society as a whole;



Source: Authors

Figure 3.
Structure of the TTICC area of the Embrapa agrobiology unit

(2) interchange of knowledge, which enables technology and knowledge already developed to be interpreted and adapted by means of specific realities and particular values; and

(3) collective construction of knowledge, which seeks to build knowledge along with farmers, partners in the transfer process.

There are hence three pillars for technology transfer, interchange and collective construction of knowledge (TTICC).

As the research area develops its studies, the TTICC area is responsible for the close dialog with the target public and society at large, either through prospective studies or technology implementation (Interviewee 1). The role of the TTICC area is to build technological dialog with society, which is different from communicating, since this is the core responsibility of communication. In this new context, the TTICC area is responsible for learning the demands of society, studying its scenarios and identifying what the needs are. This information is translated into research. Knowledge is not built only on the basis of academic studies, but it is also acquired from farmers, as proposed by Fujisaka (1994), which suggests the elimination of barriers regarding the transfer of technology.

It is possible to exemplify technology transfer in this unit, whose main highlight is the production of Brazilian agriculture inoculants. As illustrated, the production of a compound with selected and studied bacteria, when in contact with the roots of plants, increases nitrogen fixation. To a certain extent, this knowledge is transferred to society through courses for farmers or technical assistance and rural extension agents (TAREA), or even through licensing structures for companies that develop studies and partnerships for technical assistance.

In TT, Embrapa's main target public is the extender or the multiplier agent. He or she may be a community leader or a coordinator of an association. This person is the individual who transmits the knowledge to other cooperative or community members. This multiplier agent then becomes the instructor of a certain community. Only in specific situations does Embrapa work directly with farmers, such as in the National Plan for Innovation (NDA) for family farming. In this case, the company receives funds from the federal government to carry out training actions directed to farmers. This does not have the intent to be some sort of technical assistance. Instead, it is a form of empowerment that Embrapa gives to farmers so they can become multiplier agents.

Embrapa does not have sufficient resources to directly reach all farmers. Therefore, the target is multiplier agents. They are the disseminators of technology and the people who transfer knowledge to the end users (producers). A farmer will not always return to the company once, twice or three times to continue training, but the multiplier agent does. So, the current proposal is to continue with the training of these agents. Embrapa is seeking to identify where it has been working, what its productive chain is and for which technology it has been trained. That is, Embrapa is trying to map out these agents so that it can provide training for them in the future through a continuous training program.

The focus on multiplier agents has become stronger with the establishment of the DTT, but some of Embrapa's units already worked that way. The Embrapa Cerrados Unit, for example, is a reference of this link between EMTAREAs and the company. This ends up being more effective by the fact that multiplier agents are within the company in a continuous training program.

The major difference is that Embrapa, rather than developing knowledge or technology and then transferring it, hopes to discuss together with producers what the best way might be. It is about doing "with" instead of "for" the farmer. There is a big difference in this,

especially in how technology is approached and how it is interpreted and accepted by the producer. In the old model, the company transferred a technology, but the producer needed something beforehand. So, there was work to be done together to enable understanding the reality of producers, their real needs and the impacts that a certain technology can cause.

In this new phase of TT, the exchange of knowledge stands out, which is a way of building together. This is more than transfer. It is logic of collective construction in which researchers work together with producers to generate knowledge and to transfer it. Producers are the ones who know the place and the context of the problem, so they bring information to Embrapa's researchers. For example, in a process of rainwater capture, it is the producer who knows the rainfall history of a determined area. Embrapa then begins to adapt and to transform this technology and to enter the reality of the producer. Without this interchange of knowledge, that is not possible. Thus, this new focus and way of constructing research and transferring it to the producer is advantageous.

This exchange of knowledge and experience occurs during the entire process, even during the validation of the technology. The multiplier agent takes knowledge to producers and later returns to Embrapa with the results. This process already generates new knowledge by providing feedback regarding the actions of the research. It often works with social technology, enabling Embrapa researchers to keep up with farmers needs based on common sense, which then turns into research. Innovation arises from the original knowledge of the farmer, which is then transformed into scientific knowledge.

4.3 The technology transfer process

The process of technology transfer is very diverse and there is still a culture of shelving/storing technology. A shelved study means that Embrapa produces the research and then transfers it to farmers, without their involvement in the development process. However, the company has been working to change this culture, since many have recognized that there is no transfer without the direct dialog with and participation of farmers in the process (Interviewee 2). A trend in this new way of transfer is the use of the farmers' own properties. For a long time, Embrapa exclusively used its experimental farms, called Technological Reference Units (URT), where transfers were made through demonstrations. However, Embrapa's URTs prefer to engage in TT on the farmer's property. Therefore, the farmer feels part of the process and is involved in this transfer.

TTICC can be made in different ways, provided they are within the Embrapa Manual of Forms of Delivery and Results. Embrapa works with seven main ways, which are presented as follows (Embrapa, 2016):

(1) Training for multiplier agents, which is organized and carried out by the Unit or in partnership with other Units and other institutions, registered internally, giving certificates containing study time, content and duration of at least eight hours, as described in the new Embrapa Manual of Events. Certificates can be issued in the Unit's facilities or in external locations.

(2) Field day, which is an event aimed at practical demonstrations or imagery (field day on TV) of the results of the research or of the technologies developed, adapted or adopted by Embrapa, through visits to experimental fields of the Company, technology showcases, agro-industrial plants and demonstration areas. The multiplier agent or the producer visits the stations, for example, the organic vegetable station, the seedling station, until arriving at the production field of vegetables themselves. This is one of the main TT instruments of Embrapa.

(3) Technical lecture, which is a presentation on technical or scientific topic, with the purpose of promoting the shared knowledge in an indoor and outdoor event at the Unit, with a minimum duration of 45 min.

(4) Incubation process, which is a technology transfer process that encourages the creation, development and consolidation of competitive companies through the adoption of modern administrative practices and the uptake of innovative technologies.

(5) Learning unit, which is the primary way Embrapa transfers technology. It is about separating a part of an Embrapa field to receive the farmer. In this part, the company researches and receives farmers to carry out the transfer. However, the company has come to realize that some farmers believe that "the soil of Embrapa is better", so the tendency is that farmers may take their own ownership to be a learning unit. Thus, the farmer becomes partner, and along with him, the company develops knowledge. In the Embrapa Agrobiology Unit, there is a learning facility called "Fazendinha Km 47" that has an area of 80 hectares. It receives about 1,800 visitors annually in its trainings, field days and technical lectures for the interchange of knowledge and experiences among undergraduate and graduate students, researchers, professors, multiplier agents and farmers.

(6) Observation unit, which is a space that allows the observation or validation of results generated by Embrapa or its partners, in their evaluation phase, in different environments and times. The installation of an observation unit can occur through Embrapa or in partnership with other organizations, in their own areas or through third parties, with the collaboration of producers, cooperatives, public or private research institutions.

(7) Demonstrative unit or technology reference unit is a space for demonstration of the results of technologies generated and/or adapted by Embrapa and partners, in the form of final products. It can be installed inside or outside Embrapa's Unit, but under its supervision, in partnership with education, research and technical assistance and rural extension agencies (private or official). It acts as an irradiating center for technology transfer and for the interchange of knowledge, in general, associated with training and capacity-building efforts of multiplier agents. Rather than giving a packet of seeds to the producer, for example, Embrapa makes the demonstration of the use of the seeds, in situations with and without the use of the seeds, in which the producer can learn in theory and in practice.

Embrapa relies on two other forms of delivery, which are the systematization of experience, in which it works together with farmers to systemize and plan, while the other is the formation of socio-technical networks, in which interchange of knowledge occurs, that is, the exchange of knowledge between the company's researchers and farmers or agents. This is in addition to fairs and exhibitions, which are new forms of TT. In this case, present technological solutions from all Embrapa units. This is a proposal to work in networks, which is something that Embrapa is also focusing on, both among units and among external partners. There are projects in which other units are involved, because each researcher has his/her own contact network. Each unit has its own expertise, in the case of Agrobiology it is socio-environmental and rural development, but Agrobiology needs to work in unison with other units to develop its projects.

In addition to the forms of delivery (1 to 7), Embrapa has a commitment to society, which is reflected in its annual publication, since 1997, of a social balance sheet. This report shows

Embrapa's results for the year and is available on the Internet. And finally, scientific publications are also a way to transfer knowledge. Embrapa has its own scientific journal and its researchers also publish papers in other journals in Brazil and worldwide. This is also a form of socialization of the developed knowledge.

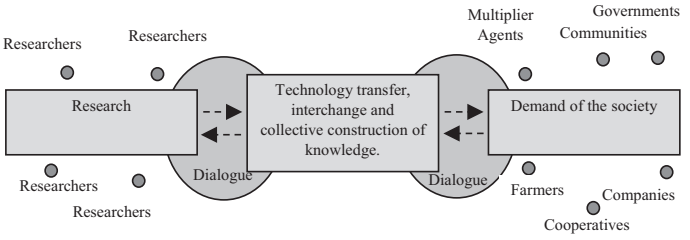
Many of these forms of delivery are used, but it is important to say that the validation of a particular technology occurs only with producers and cooperatives or other actors involved in the TT process. So, when a technology is launched, it already presents some farmers' expertise because they participated in the construction process. Therefore, it does not become a novelty to them, because it was developed altogether. In the case of programs aimed at specific publics such as "Brazil without Mysery" (Brasil sem Miséria), the public is smallholders, for whom Embrapa adopts as a form of delivery the Learning Reference Unit (URA). In this case, the company builds a URA together with the producers and they learn together with the company how to use the technology. From this, these URAs have become showcase models of the developed technology and a space for training other multiplier agents.

Each unit has its own mode of operation, but the Embrapa Headquarters Unit is trying to create a more institutional process and more methodological procedures. Still, each unit is free to act in the way it considers best. However, the Headquarters Unit tries to be a guiding force for these actions. Figure 4 illustrates the process of production of technological solutions, in which technology transfer has a key role. The demands of society go to the TTICC, which in turn produces research and technology transfer, giving the benefits to society. The importance of dialog between society and research stands out in this process, which can occur via interchange of knowledge and collective construction. The contact made between researchers and society always passes through the area of technology transfer.

Although it is not the focus of this study, it is important to note that the actions involving society are monitored to see if farmers are adopting certain knowledge and if it is causing economic or environmental impact in the community around them. From then on, Embrapa uses a method to assess and measure the adoption of technology. These results are reported in the social balance sheet, showing how much a technology has increased farmers' productivity, as advocated by Janis (2003).

4.4 The role of the government in innovation at Embrapa

About the government's role in innovation, it clearly has greater responsibilities than regulating and creating laws. Embrapa needs to know how far it can go, who owns the right to intellectual property, and these are also the responsibility of the government. But there is also another side, which is to foster innovation through the resources and conditions given to Embrapa for research in agriculture, as well as promoting dialogue between society, companies and Embrapa.



Source: Authors

Figure 4.
TTICC in the process of production of technological solutions

Research and innovation depend on good conditions provided by the government. Without the support and incentive of the government, there are no conditions for research and for generating results. The role of the government is to provide the resources to make this happen, and that role has been carried out during Embrapa's history despite the restrictions in recent years due to the economic crisis (Interviewee 1).

Due to the numerous changes in productivity and organizational systems, the university-business-government relationship should be strengthened, as noted in the study of Silva, Kovaleski and Pagani (2019), so that each actor assumes a role. Organizations and universities, as well as the government, must work to ensure development through technology transfer.

5. Final considerations

The aim of this study was achieved, since there was a possibility of describing and analyzing the technology transfer process at the Embrapa Agrobiology Unit, located in the city of Seropédica, Rio de Janeiro. We can conclude that Embrapa has been committed to involving farmers in the process of interchange, collective construction of knowledge and technology transfer. Farmers have become the focus of this process, reducing the development of shelves technologies and increasing the participation of farmers or multiplier agents.

We can also conclude that Embrapa is dedicated to bringing knowledge to the most important people involved in this process: farmers. To this end, in a new phase of technology transfer, the multiplier agent became a focus, since it is more likely to work together with Embrapa, to disseminate knowledge to other farmers through cooperatives, communities and associations, as well as multiplier agents to bring into the Embrapa the real demands of other producers. The transfer of technology by itself is not enough to promote transformation. It is rather necessary to exchange knowledge with farmers and build research collectively. This is the best result and it is what Embrapa has invested its efforts in.

The importance of studying and knowing the process of technology and knowledge transfer to the public should be highlighted, and especially the reasons why this technology or knowledge is often not adopted by the public. It was possible to identify that Embrapa has noticed the difficulties of farmers and realized that the best way of transforming technological solutions and knowledge into innovation is by involving farmers in the process of construction and transfer. So it is better to buy the technology than to know, because this knowledge is something that they helped build.

In the sphere of contemporary institutional knowledge management, Embrapa has had as its main point of departure the demand and the needs of society. For this, it has created means to ensure the participation of different players because they signal the construction of technological solutions and innovation and they are the ones who know the real situation. However, this is a recent development within Embrapa, which has evolved and generated results. Thus, research, science and technology institutions must go beyond technology transfer and must ensure the involvement, participation, and interaction of the public to promote significant changes, i.e. social, economic and environmental development and transformation. Embrapa has done this through the inclusion of the exchange of knowledge and the collective construction of knowledge in the transfer of technology.

In addition to contributing to the development of products, processes and technologies for the economic, social and environmental development of Brazil, Embrapa has been outstanding in generating knowledge for the advancement of science. Its results have had impacts not only nationally, but worldwide. Embrapa has played a key role in Brazilian farming and livestock breeding, mainly, in supporting governmental projects and in the implementation of public policies.

Embrapa is committed to promoting the process of technology transfer with the same institutional dimension of the R&D macro-processes (integration of R&D, TT, communication and business, as the beginning of the innovation management process; promotion of dialog with partners in the definition of TTICC strategies, considering the characteristics of the different audiences and the diversity of agroecosystems; stimulating the integration of social actors as the subjects of the innovation process; and valorization and support of local innovation networks in the TTICC process, as proposed in the guidelines in the Referential Framework.

This study contributed to reflections about the TT process and how it can be used by different players, along with the role played by the government regarding innovation. However, some limitations should be mentioned, among them the fact that only members of Embrapa were interviewed, limiting the analysis to the TTICC staff and without knowing the opinions of multiplier agents and other actors involved in the process. In addition, it is a qualitative study that is subject to the interpretation of the researcher.

Thus, we suggest as further research other interviews with other players involved in the TTICC process internally and externally to Embrapa, as well as the heads of other departments. We believe that the opinions of farmers and agents, as well as of government representatives, could complement the analysis of this process. The analysis of the farmers' opinions would be interesting to investigate the troubles faced in adopting technologies as well as why they are often not adopted. Thus, another possibility would be to study how technology could be transferred more efficiently, dedicating more time and people to the systematization of the experience.

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