THÈSE POUR OBTENIR LE GRADE DE DOCTEUR
DE L'UNIVERSITÉ DE MONTPELLIER

En Sciences agronomiques

École doctorale Gaia (Biodiversité, Agriculture, Alimentation, Environnement, Terre, Eau)

Unité de recherche : UMR Espace-Dev

Titre de la thèse en anglais: Conceptual Model of the Impact Assessment of Innovation - case studies from agricultural research organizations in France, Brazil, and Australia

Titre de la thèse en français : Modèle conceptuel d'évaluation de l'impact de l'innovation - basé sur des études de cas des organisations de recherche agricole en France, Brésil et Australie

Présentée par Sávio BARROS DE MENDONÇA

Le 5 Septembre 2019

Sous la direction de Anne-Elisabeth LAQUES

Devant le jury composé de

Jean-Philippe TONNEAU, DR, CIRAD, France	Président du jury
Moïse Tsayem DEMAZE, Professeur/HDR, Le Mans Université, France	Rapporteur
Francisco RAMOS, Professeur, Université Fédérale de Pernambuco, Brésil	Rapporteur
Gilbert DAVID, DR/HDR, IRD, France	Invité
Anne-Elisabeth LAQUES, DR/HDR, IRD, France	Directrice de thèse

UNIVERSITÉ DE MONTPELLIER

Acknowledgments

I especially thank my thesis supervisor, Anne-Elisabeth Laques, for the guidance and providential methodological support, extended to the strategic and methodological help of Professor Carlos Saito of the University of Brasilia. I want to thank Nadine Dessay for her important help and contribution, from the most routine to the most strategic moments during my stay in Montpellier and the UMR Espace-Dev, including her participation in my thesis committee. I also want to thank Agnes Begue for coordinating my thesis committee and for her important collaboration in the thesis' construction. My thanks to the honorable participation and contribution of Jean-Philippe Tonneau in the thesis committee. I thank Odyssea project for making it possible to carry out the field experiences, as well as for all members, staff, researchers and administrative team of UMR Espace-Dev, extended to Marie-Paule Bonnet and Laurent Durieux, as well as for all IRD and University of Montpellier teams. Special thanks to Frederique Seyler for hosting me to the UMR Espace-Dev, as well as to Agnes Clemente, Sylvie Laleu, Veronique Rousseau and Veronique Jalabert by the warm welcome and support, and Marina Hohl for all support during my field works by the Odyssea project. Special thanks to Frederic Huynh (from IRD) for the encouragement and consolidation of France-Brazil partnerships. Many thanks Douglas Conches, from Banco do Brasil – Lucas do Rio Verde Agency, for important information on rural credit for producers. I thank National Confederation of Agriculture and Livestock (CNA), as well as to Agriculture Federation of the State of Mato Grosso (Famato) for their important data of agricultural sector and analyzes on their relationship with the agricultural research. Thanks farmers of the State of Mato Grosso, especially teams of Bacaeri Farm (especially for Fernando and Augusto Passos), Caregi Farm, Platina Farm (with special thanks for Waldemar Antoniolli), for their cordiality and attention during my technical visits. My thanks workers of rural technical assistance, especially for Alberto of Konsultec and Ademir. Finally, I want to thank Embrapa for making this thesis feasible, especially for Pedro Machado during his stay at Labex-Europe and all his support and participation with the important contribution in my thesis committee. I also, thanks the advice and support of Embrapa Agrosilvipastoril's colleagues, such as Austerclinio de Farias Neto, Laurimar Vendrusculo and Flávio Wruck, to the colleagues Margareth Simoes, Embrapa Solos, Geraldo Stachetti, Embrapa Meio Ambiente and especially to my academic advisor Graciela Vedovoto, from Embrapa Headquarters. I especially thank my wife Helen for her patience and important help at key moments throughout the process. I thank my daughters Clarissa, Ana Luisa and Alissa, my mother Ilza, my sisters Jurilza, Lelia, Sonia and Adria as well as my brothers Flavio, Cleuter, Fabio and Jose Luiz for moral support and for all of my family, friends, colleagues, and everyone who has contributed in some way to the achievement of this work.

Sávio

Préambule

Au cours des dernières années, mon établissement (l´Embrapa) s´est montré chaque fois plus préoccupé par la nécessité d´améliorer son système d'évaluation de l'impact de la recherche.

L'administration de l'Embrapa fait partie intégrante du comité du ministère brésilien de l'Agriculture qui définit les politiques agricoles du pays. Ses membres ont une grande influence sur le format de ces politiques et sur la définition des priorités de recherche et d'innovation. En outre, tout effort mis en œuvre au profit du Brésil afin de développer la production de solutions technologiques axées sur une production agricole durable sera le bienvenu, car il reste encore de nombreux progrès à faire dans cette direction.

J´aspire fortement à faire partie du processus de réflexion qui permettra a mon Institution d'améliorer sa position face a la façon de conduire la politique agricole du pays en tant que membre du comité directeur de recherche de l´Embrapa. C'est cette volonté d'agir, de pouvoir influer qui m´a encouragé à solliciter l'autorisation de faire un doctorat avec l'ambition de participer a ce moment important de mon institution.

Aussi, une fois ma demande approuvée, j´ai décidé de relever ce défi. En tant que titulaire d´un doctorat, j´aurai par la suite de grandes chances d´accéder à des postes de direction au sein de mon institution et donc d´être en mesure de l´appuyer dans l´implantation de ses politiques, stratégies, et autres projets de recherche ciblés sur l´expansion de la production agricole durable.

Les expériences sur évaluation d'impact de la recherche réalisées par les organismes françaises pourraient apporter de nouvelles connaissances sur le sujet. Ma femme avait déjà terminé son doctorat en France et avait des références positives issues de son expérience. Mes collègues ont également fourni des informations positives sur la période où ils ont obtenu leur doctorat en France. Cette atmosphère, alliée à la riche histoire française dans le domaine de l'agriculture et aux bonnes relations entre le Brésil et la France, dans le domaine des échanges scientifiques et de la coopération, m'a incité à choisir de faire ma thèse dans la France.

Résumé

La recherche en agriculture a un rôle important à jouer pour la population mondiale si on la considère comme un domaine stratégique pouvant fournir des connaissances ainsi qu´une base technologique à la production agricole. Ce secteur génère des extrants, des résultats ayant des impacts spécifiques dans les zones rurales, les filières agricoles, l'économie, la société et l'environnement. La recherche et l'innovation agricoles représentent un élément clé pour permettre d´atteindre les objectifs du développement durable imposés par les Nations Unies (ODD), en particulier les ODD 2 et 12 – c´est-à-dire réduire les inégalités sociales, éliminer la faim et accroître durablement la production alimentaire. Ainsi, l'évaluation de l'impact dans le domaine économique, politique, social et environnemental des recherches et des innovations devient fondamentale dans un objectif de recherche croissante de la durabilité des pays et de la planète. Les bailleurs de fonds, les institutions supérieures de contrôle, le parlement, le gouvernement, les producteurs, les filières agricoles, les consommateurs et toute la société civile ont besoin de transparence, d'efficacité et d'efficience de la part des organismes publics : ils doivent démontrer un retour sur investissement public, un impact positif sur l'économie et la société, tout en minimisant les impacts négatifs sur l'environnement. L'objectif principal de cette thèse est donc de répertorier les approches théoriques et pratiques déjà réalisées pour l'évaluation d'impact, en particulier en se penchant sur les expériences de quatre organismes de recherche, et de développer un modèle conceptuel du système de gestion de l'évaluation d'impact de l'innovation, en particulier un modèle qui sera applicable aux organismes de recherche agricole. Nous adoptons une méthodologie basée sur la revue de littérature, quatre cas d'étude comparative d'organismes de recherche agricole (le Cirad et l´Inra en France, l´Embrapa au Brésil, et le CSIRO en Australie). Les contributions innovantes de cette thèse sont : I. La construction d'un modèle conceptuel d'un système de gestion de l'évaluation d'impact basé sur le processus d'innovation ; II. Le modèle du système de l'évaluation d'impact d'innovation considérant une vision transversale de durabilité, intégrant les dimensions environnementale, sociale, politique et économique ; III. Le système d'analyse d'impact de l'innovation reposera sur un processus unique de gestion, notamment concernant les étapes d'évaluation ex ante et ex post selon leur temporalité respective ; IV. La gestion du processus de l'innovation et de l'évaluation d'impact prévoyant l'insertion d'approches comportementales telles que les concepts d'holisme, de constructivisme et de transdisciplinarité. Cette thèse présente donc une approche originale car fournissant un outil de gouvernanceà la recherche, tout en mettantun accent innovant sur la gestion de l'impact ex-ante et ex-post. Elle aide les organisations de recherche et d'innovation à fournir chaque fois plus de solutions durables dans le cadre de leurs missions institutionnelles, et contribuant ainsi à participer aux objectifs de développement durable de l'ONU pour aller vers une agriculture plus productive et plus durable.

Mots-clés : constructivisme, durabilité, évaluation d'impact, holisme, innovation, recherche agricole, solutions technologiques, transdisciplinarité.

Abstract

Agricultural research has an important role for the world population by considering it as a strategic area for providing knowledge and technological base for agricultural production. This sector generates outputs, outcomes with respective impacts to rural zones, supply chains, economy, society and environment. The agricultural research & innovation represents a key piece for reaching the United Nations sustainable development goals (SDG), especially to SDG 2 and 12 – to promote sustainable agricultural to eliminate hunger and improving nutrition, as well as to promote sustainable consumption and production, respectively. In order to check whether agricultural research organizations generate sustainable impacts, it is necessary to assess the impacts of their innovations. Funders, supreme auditing institutions, parliament, government, producers, supply chains, consumers and all society require transparency, efficacity, and effectivity of public organizations: they must highlight return of public investment as well as generate positive impact to the economy and society, and minimize negative impacts to the environment. Many public research organizations around the world have developed impact assessment processes. There is no flawed theories and practices approaches to impact assessment context. Therefore, this research seeks to fill gaps or to supplement the existing approaches. The main thesis objective is to summarize theoretical and practical studied approaches on impact assessment, including the experiences of four research organizations, and to develop a conceptual model of innovation impact assessment management system, especially applicable to agricultural research organizations. It adopts a methodology based on literature review, four cases of a comparative study of agricultural research organizations (Cirad and Inra from France, Embrapa from Brazil, and CSIRO from Australia), and benchmarking these experiences studied. The innovative contributions of this thesis are I. construction of a conceptual model of an impact assessment management system based on the open innovation process; II. the model of innovation impact assessment management system considers a cross-cut view of sustainability, integrating the environmental, social, political and economic dimensions; III. the innovation impact assessment system will be based on a unique managerial process that regards *ex-ante* and *ex-post* assessment stages according to its respective temporality; IV. the management of the innovation and impact assessment processes foresees the insertion of behavioral approaches such as concepts of holism, constructivism, transdisciplinarity and agile management practices as essential requirements for the effective engagement of the internal and external actors and the effectiveness of the evaluation process. This thesis has an original approach by bringing a research governance tool with an innovative focus on *ex-ante* and *ex-post* impact management, helping research and innovation organizations to become increasingly sustainable in their institutional missions, thus contributing to the achievement of the UN's sustainable development goals towards more productive and sustainable agriculture.

Keywords: Agricultural Research, Constructivism, Holism, Impact Assessment, Innovation, Sustainability, Technological Solutions, Transdisciplinarity.

Resumo

Como área estratégica, ao fornecer conhecimento e base tecnológica para a produção, a pesquisa agrícola tem um papel crucial a desempenhar à população mundial. Este setor gera produtos e resultados, com respectivos impactos nas áreas rurais, cadeias produtivas, economia, sociedade em geral e meio ambiente. A pesquisa e a inovação agrícolas são um elemento-chave para alcançar os Objetivos de Desenvolvimento Sustentável (ODS) das Nações Unidas, especialmente os ODS 2 e 12 - promover a agricultura sustentável para eliminar a fome e melhorar a nutrição, assim como promover consumo e produção sustentáveis, respectivamente. Para validar se as organizações de pesquisa agrícola geram impactos sustentáveis, é necessário avaliar os impactos de suas inovações. Os financiadores da pesquisa, tribunais de contas, poderes legislativo e executivo, produtores, cadeias de valor agrícolas, consumidores e a sociedade em geral precisam de transparência, eficiência e eficácia das instituições de governo ligadas à ciência e tecnologia. Estas devem demonstrar retorno do investimento público, gerar impacto positivo na economia e na sociedade, bem como minimizar os impactos negativos ao meio ambiente. Muitas organizações públicas de pesquisa em todo o mundo têm desenvolvido processos de avaliação de impacto, salientando que, não existem teorias e práticas perfeitas nesse contexto. Assim, esta tese pretende preencher lacunas ou complementar as abordagens existentes. Seu principal objetivo é resumir as abordagens teóricas e práticas estudadas sobre avaliação de impacto, incluindo as experiências de quatro organizações de pesquisa, e desenvolver um modelo conceitual de sistema de gerenciamento de avaliação de impacto da inovação, especialmente aplicável às organizações de pesquisa agrícola. Adota uma metodologia baseada em revisão de literatura, quatro estudos de caso de organizações de pesquisa agrícola (CIRAD e INRA na França, Embrapa do Brasil e CSIRO da Austrália), adotando um processo de benchmarking como consequência dessas experiências. As contribuições inovadoras desta tese são: I. A construção de um modelo conceitual de um sistema de gerenciamento de avaliação de impacto baseado no processo de inovação aberta; II. O modelo considera uma visão transversal da sustentabilidade, integrando as dimensões ambiental, social, política e econômica; III. O sistema de avaliação baseia-se em um processo de gestão único, focando as fases de impacto *ex-ante* e *ex-post*; IV. A gestão do processo de inovação e do sistema de avaliação de impacto prevê abordagens comportamentais, associando conceitos de holismo, construtivismo, transdisciplinaridade e práticas de gestão ágil, como condição do efetivo engajamento de atores internos e externos à organização de pesquisa e o consequente sucesso do modelo. Esta tese tem uma abordagem original ao fornecer uma ferramenta de governança da inovação com foco na gestão integrada do impacto *ex-ante* e *ex-post*, ajudando as organizações a se tornarem cada vez mais sustentáveis, cumprindo suas missões institucionais e contribuindo para o alcance dos ODS da ONU, tendo em vista a busca de uma agricultura ainda mais produtiva e sustentável.

Palavras-Chave: Avaliação de Impacto, Construtivismo, Holismo, Inovação, Pesquisa Agrícola, Soluções Tecnológicas, Sustentabilidade, Transdisciplinaridade.

Liste of Figures

Liste of Tables

Contents

Introduction

What is happening to the world regarding agricultural sustainability, the sustainable development goals and their challenges and problems related to the agricultural research impact?

The world undergoes rapid and innovative changes in all fields of society. The technological, economic, social and environmental transformations have carried the United Nations – UN - to take a leading role in the global discussions, agreements and political definitions towards increasingly sustainable development. In this context, the UN has launched the 17 Sustainable Development Goals (SDG) to be implemented by 2030 (UN, 2015).

Among these goals, SDG 2 establishes that hunger and malnutrition must be eliminated by sustainable agriculture, and SDG 12 is issued on sustainable consumption and production (UN, 2015). Thereby, agricultural research and innovation organizations have an important role in generating more and more sustainable technologies, products, processes and services that should be measured by a management system of impact assessment.

Especially after the end of World War II, the agricultural sector has moved substantially towards increasing food and fiber productivity. These facts resulted in new technologies, mechanization, that simultaneously increased chemical use, specialization and government policies that promoted production growth. All these factors reduced labor demands to produce in a great part of agricultural countries, like the USA, France, Canada, Germany, Australia, Argentina, Brazil and others.

Economic risks for farmers were reduced, but at the same time, environmental and social costs have being visible: soil depletion, groundwater contamination, employment reduction in rural areas, land grabbing, swelling of cities and others. In many countries, family agriculture has almost disappeared and in others, it has been outside of the major productive process of world agribusiness, and along with the expansion of the scale of production, agroecological practices have also been reduced (Feenstra, 2018).

Although agriculture has undergone an intense modernization process over the past 70 years, there is still much to grow, however, no longer in a voracious way and without environmental concerns and fragile social responsibility. According to FAO, by 2050, the population will be 9.8 billion, 29% more than the current number and the highest growth will be in developing countries. Seventy percent of the population will be urban and income levels will be higher than the current ones. In order to feed this larger, more urbanized and richer population, food production is expected to increase by 70%. Cereal production will have to rise to 3 billion tons/year from the 2.5 billion tons produced today. Meat production will need to increase by more than 200 million tons. In this direction, one has to rethink how to produce by using sustainable solutions to farmers and all supply chain (FAO, 2017).

Nowadays a great part of research organization experiences still indicates fragmented approaches. The agriculture of the future needs to generate more social and productive inclusion in rural areas to avoid the rural exodus process that has affecting many countries around the world. At the same time, it must generate food security for local and global populations, as well as safe food to the human health, in addition to the need of using solutions that respect the limits of the environment and its necessary resilience. We need innovative technologies from a sustainability perspective towards an integrated, holistic, constructivist and transdisciplinarity approach for the innovation's process, avoiding gaps from a sustainability perspective (Asif et al., 2011; Becker, 2001; Joly, P. et al., 2016; Cato, 2009).

In this path, it is fundamental to identify ways that could help agricultural research organizations to improve their performance of innovation processes with a focus on increasingly sustainable technological production (Feenstra, 2018). Therefore, innovation impact assessment becomes the crucial stage to adjust policies, research management, research project leadership and developing an organizational impact culture extensive to their stakeholders. As an example, one of the key limits to be respected is water consumption, because of the increasing water crisis (Grey et al., 2015; Hanjra and Qureshi, 2010).

Over the last 40 years, research institutions have been improving their innovation impact assessment systems aiming to demonstrate to the government and society the research importance. Several cutting-edge research organizations around the world have been addressing the issue of innovation impact assessment of what they produce as an essential measure for improving their policies, strategies, projects and activities and so for reaching their institutional missions. Innovation impact assessment systems are essential to measure the effect of an organization's activities, its products, technological innovations, processes and services. It is basic to assess how they reach and impact on their target customers or audiences, how they affect in organizational economics, in productive chains, and also the degree of benefits that may generate. It is important to evaluate the level of impact severity and the extent to which they affect the ecology and quality of life of the social environment. Positive and negative effects must be evaluated either to the organization health or the society and environment (Asif et al., 2011).

After some literature reviews on corporate impact assessment, as well as after accessing some documents from those research organizations, it was clear that innovation impact assessment methodologies deserved deepening. Those research organizations experiences contributed to enlarge discussion on this theme. However, in their methodologies were observed some gaps to be studied and supplemented. For example, they do not consider a whole and interconnected management process of impact evaluation by viewing *ex-ante* and *ex-post* impacts to be assessed (Asif et al., 2011; (Barros de Mendonca & Laques, 2017).

It was not observed a systemic cross-cut perception of sustainability, and they usually presented an understanding that the environmental dimension is more important than the social, and this one is more important than the economic, respectively, according to the Cato approach. If we destroy or mismanage the environment, we are going to destroy or weakening the base of the economy (Cato, 2009).

The innovation impact assessment when referring to a public organization, the level of social, economic and environmental responsibility should be increased, as they must set the right example for society and well serve the public. In this context, it is known that most research organizations, including agricultural research organizations, rely heavily on public resources. Thus, evaluating the impact of their research means being transparent and demonstrating to stakeholders, supreme auditing institutions and to the government itself, but mainly to society, where and how resources are applied, and especially, the level and quality the impact of what they generate for the productive sector and economy, the environment and society (Barros de Mendonca & Laques, 2017).

Nevertheless, public resources are increasingly scarce, especially in countries where basic needs are still far from reaching the entire population. In addition, this lack of resources substantially affects research and innovation organizations, which increasingly need to show that they generate positive impacts for the society and so can secure government budgetary resources and donations or investments from funders.

Thus, the objective of this thesis is to analyze experiences in the impact assessment of the innovation of important agricultural research organizations in the global scenario- and then, to design a new innovation and improved impact assessment model, as specified below:

- Develop a proto-conceptual synthesis of innovation impact assessment;
- perform a benchmarking of positive methodological procedures for the research impact assessment of different organizations recognized in the global arena as important and influential institutions in the generation of innovation's solutions for agricultural activity, representing America, Europe and Oceania (where there are important countries in the global agribusiness scenario);
- create a conceptual model of an innovation impact assessment system that focuses on agricultural research organizations and is based on a sustainability cross-cutting perspective.

Accordingly, this thesis search to construct a new model of an impact assessment system of innovation, based on an approach that can help agricultural research organizations to evaluate the impacts of their technologies, products and services.

This model is focused on the impact assessment system and intends to print the integrated sustainability dimension in their evaluation processes by a cross-cut vision as well as inserting some behavioral principles to be considered like a requirement for its success. As a governance and management tool, it is expected that this new model can facilitate the technological innovation processes to fit into the concepts of sustainability and synchronized with the impact evaluation process by a unique managerial system. It is expected that all of this can help agricultural research organizations better serve the productive sector in producing healthy food by global demands, generating safe food and that meets food security, by enlarging sustainable production processes, according to the parameters established by the World Health Organization (WHO, 2006) and the UN's sustainable development goals.

The thesis is structured in 3 parts after this general introduction: **the first one corresponds to a literature review** and presents concept analysis from a macro approach and goes towards more specific approaches. It means that the text comes from a larger approach related to global policies, such as those related to the Sustainable Development Goals and sustainable agriculture to a more focused analysis about impact assessment and the role of innovation to these goals of sustainability.

The second part is dedicated to a methodological section, presenting the steps to produce a proto-model and how four institutions were chosen to take part in the benchmarking process.

The third part presents the main results of each step and how these previous steps led to the final conceptual model of an innovation's impact assessment management system.

Part I - Literature Review – Concepts and Approaches

1. Towards a Sustainable Agriculture

Sustainable production must be pursued, and agricultural research organizations are key institutions in the search for increasingly sustainable technological solutions in collaboration with other government measures.

In 1992, for the first time the United Nations cited in its documents vehemently the concern with consumption and sustainable production, which represent essential factors in restructuring the development model that has been underway.

In 1994, at the Oslo Symposium, the discussion went deeper, and the nations represented reported about urgency for UN measures towards sustainable production and consumers patterns: "the use of services and related products, which respond to basic needs and bring a better quality of life while minimizing the use of natural resources" (UN, 2019).

In 2002, the UN established that within ten years a concrete agenda with a schedule and measures to stimulate sustainable production and consumption should be built. In 2003, this decision was officially signed, during the Marrakesh round and in 2012; during the Rio + 20 Conference the theme is included in paragraphs 224 to 226 of The Future We Want document. In 2015, in the First Global Meeting for the tenth year of Sustainable Production and Consumption, the theme was inserted in the Goals for Sustainable Development Agenda, as Goal 12 (UN, 2019).

By its agencies and programs, the UN has taken initiatives to stimulate sustainable production and consumption and, in that direction, has encouraged governments to mobilize public and private organizations to integrate into this global effort.

For example, the UN has created specific years as occasions to celebrate relevant events or topics in order to promote, by awareness and action, its Organization's goals. Usually one or more Member States propose these commemorative years and the General Assembly establishes them using a resolution. Each UN organism, as Unesco, UNEP and others, coordinate the actions of celebration year according to its specific attribution (UN, 2019).

For stimulating the food production were set, in 2004 the International Year of Rice (the most popular and consumed cereal around the world). Like the International year of Potato, in 2008, important food as an energy source, or the International Year of Quinoa, in 2013, as an important protein alternative. In order to stimulate sustainable use of natural resources, the UN created in 2006, the International Year of Deserts and Desertification, considering fragile soils and dried zones around the planet where million of hungry or undernourished populations live.

Considering the worry about the use of natural resources for food, timber products, bioenergy and fiber production systems, it was established the International Year of Biodiversity in 2010, the International Year of Forests in 2011, the International Year of Water Cooperation in 2013, and the International Year of Soils in 2015. (UN, 2019). A brief overview of the UN Decades and International Years can be found in Saito (2017), in which the author concludes that food and water have been the main mainstreamed issues.

As Rio+20 effects, in June 2014, in Seoul, the UN in partnership with The International Organisation of Supreme Audit Institutions (INTOSAI[1]) and the World Bank Institute accomplished the workshop Innovating Governance for Sustainable Development and Well-being of the People. One of the most important results of this workshop was a document which included several measures to be implemented by superior courts of public accounts of INTOSAI members of countries, as "contribution to good governance and promoting sustainable development through citizen mobilization and participation in public auditing processes" (UN, 2015).

INTOSAI, by its 23rd symposium, established on that meeting that the Sustainable Development Goals (SDG) should be chased by governmental organizations and therefore, they have to utilize public resources correctly, by generating positive impact to society and by transparency way. For instance, a great part of agricultural research organizations (as focused on this thesis) is governmental institutions or employ public resources. "In this regard, supreme audit institutions will need to continue strengthening their traditional financial and compliance auditing functions to help ensure that public resources are

[1] A consultative organization of the United Nations.

allocated and spent efficiently and effectively for advancing the implementation of the SDGs" (UN/INTOSAI, 2015).

The United Nations Sustainable Development Goal 2 establishes that countries must eliminate hunger and malnutrition on the planet for present and future generations, by achieving sustainable production (UN, 2017). Before SDG, the Millennium Development Goals (MDGs) established in 2000 sought to eradicate extreme poverty and hunger. In 2009, world leaders in the World Summit on Food Security adopted a final summit declaration with renewed commitment to eradicate hunger from the face of the Earth (UN, 2017).

Goal 12 of Sustainable Development set the importance of seeking sustainable ways of producing, and that all supply chains should be engaged in this purpose. All 17 objectives have interface, 2 and 12 have a close, direct and indissociable relationship (UN, 2017).

Pursuing sustainability in agriculture represents an essential effort to getting food security. Sustainable agriculture can be defined as the agriculture that meets society's food and fiber needs in the present without compromising the ability of future generations to meet their own needs, looking for a healthy environment, economic profitability and social equity. All members of the food system (growers, food processors, distributors, retailers, consumers and waste managers) have to be involved for ensuring a sustainable production along the agrifood system (Feenstra, 2018).

The market and social pressure design an inescapable trend reinforced by the scenario mounted by the United Nations on its agreements and mandatory decisions to the countries. These local social and international political environments indicate that sooner public institutions from nations broaden the practice of building impact assessment systems into a more routine process. These efforts require sustainability policies and sustainability strategies interconnected with operational actions on sustainability, by an integrated process, induced by national laws and by international agreements or even by societal pressure (Barros de Mendonca & Laques, 2017).

It is necessary a set of factors as public policies in several economic, social and environmental sectors, but literature, public experiences and the productive sector demonstrate the strategic importance of research and innovation in the search for increasingly sustainable agriculture in the economic, social and environmental fields.

For the planet reaching a reasonable standard of sustainability, it is urgently necessary to rethink the economic model of development. While conventional economics focuses on environmental impacts as externalities, it would be much more convincing if it could concentrate not as an outside dimension, but as an internal part of the economic, social and ecological balance sheet, in a weighted and transversal measure of sustainability. The Green Economics approach focuses on the planet balance and social quality of life and considers economic dimension as a universe dependent of society, as well as, the latter inserted in a larger context called environment (Cato, 2009).

At the same time, a Green Economics implies an approach by a holistic vision, which means high participatory level in its implementation process, respect, and integration for all disciplines related to the sustainability issue. There are components of nature that cannot be monetarily valued because they are invaluable given their interaction and inter-influence on the complex systemic environmental balance. They are also worthy of a cultural or even spiritual nature that cannot be monetized (Cato, 2009).

It is necessary to rebuild society and economy, based on parameters far from the voracity of consumption that has been creating standardization of tastes, which has led to consumption standardization and consequently large-scale agricultural production systems with few commodities, expanding the loss of biodiversity, the use of agrochemicals, the contamination of soils, water and people (Feenstra, 2018; Cato, 2009).

It leads us to verify that within the environment there is intrinsically the economy of mineral exploration and all the industrial chains linked on it; has the economy of agriculture that uses soil and water to produce, but which depends on atmospheric and climatic factors, and generate impacts on the entire supply chain of agro-industry and commercialization. It is visible that forestry activity depends on to capture resources on the natural or planted forest for its economic sustainability (Barros de Mendonca & Laques, 2017; Cato, 2009).

There is an economic base that feeds on biodiversity to renew genetic stocks of plants and animals to agricultural and livestock production, in addition to the natural economic stocks that can be a consequence of sustainable forestry management. Moreover, those possible future uses of biodiversity resources that are still unknown by science and that can supply large chains of economic value in the production of food, medicines, cosmetics, enzymes, and bioenergy (Barros de Mendonca & Laques, 2017; Cato, 2009).

Technological research has its economic value because it will be connected to markets in a logic of innovation, and this has its economic and social value because it generates jobs and income, which is essential for the sustainability of society. However, natural resources and the entire environment need to be understood and used responsibly, to avoid irreparable damage or severe and extensive negative impacts over time, requiring a long period to achieve its resilience. Hence, basic research cannot be relegated to oblivion or left to peripheric planning, since the natural environment needs to be increasingly known in its structures and processes in all its ecosystemic complexity, and this demands time, dedication and financial resources.

Therefore, in the process of decision-making, it is necessary to consider equal importance of all three dimensions, from an environmental, social and economic impact perspective according to contingency measures related to budgets or emergency investments based on momentary priorities. Additionally, the environmental and social dimensions must be considered with ethics and responsibility in the decision-making process, assessing the risks of negative impacts from one dimension on the other in their reflexes regarding time resilience or irreversibility of impacts. Economic dimension should be included addressing the return on investment over the time dimension, combined with a risk factor of irreversibility of environmental recovery and resilience conditions. A mathematical analysis could be developed through a formula to be further discussed in future researches by justifying this theoretical approach.

A society without economic activity and with a low degree of education and fragile management for sustainability could soon exhaust natural resources, extinguishing its economic capacity once and for all. Even whether nature is to be conserved it is necessary to invest economically, although the return of this environmental investment sometimes comes in the long term, but with the stocked and well-based economic structure for future social and economic sustainability.

Within this context and focusing on sustainability impacts' analysis, research & innovation organization by considering the evaluation of the impact of its activities, outputs, and outcomes, must consider a sustainability balance as a result of its policies, strategies and research projects.

2. The Role of the Research & Innovation to the Sustainability

Based on the Brundtland Report (UN,1987), the General Assembly of the United Nations approved the Agenda 21 by synthesizing the sustainable development concept as a development that must promote economic growth while respecting conservation and the environment and providing social equity and access to a dignified quality of life to the present and future society (UN, 1992).

Economic growth is necessary, but it is not unique to sustainability. For this one, political, social and environmental factors must be added to make it effective. To overcome the complex challenge of integrating these dimensions, the role of research and technological innovation becomes crucial and indispensable. Social innovation and creative economy are vital factors for increasing the innovation process, as an intensive and wide process of interaction with stakeholders (Fachinelli, D'arisbo and Maciel, 2014).

It is necessary for organizations to replace their stuck productive processes, products and stuck services based on old practices and with low sustainability rates for other ones, supported by principles, objectives and guidelines capable of leading to sustainable development. This replacement depends on innovation: a sustainable innovation. Moreover, this new attitude goes through all types of organization, an essential condition for it to remain alive in an increasingly dynamic and demanding market environment for social and environmental responsibility (Barbieri et al., 2010).

The importance of technological factor in the development of agriculture can be identified, for instance, by seeing indicators of the recent trajectory of Brazilian agriculture relating the production numbers versus productivity indexes. Between 1975 and 2017, grain production, which was 38 million tons, grew more than six-fold to 236 million, while planted area only doubled, proving technological efficiency going towards more sustainable agriculture, relatively reducing horizontal space and increasing vertical one (understood as saving space) (Embrapa, 2017).

Research & Innovation (R&I) is one important activity of this process, but it is not enough. It is also necessary a set of interconnected factors with that, including public policies, financial conditions favorable to production, logistics network, technical and managerial capacity, marketing, education of the rural producer, environmental awareness of the actors throughout food supply chains.

By searching a parallel analysis between a hypothetical agricultural research organization's policies, strategies and priorities with the United Nations Sustainable Development Goals and looking ahead to the sustainability lens through an *ex-ante* innovation impact assessment system, this research organization should aim to the generation of sustainable technological solutions. The research represents an important axis for promoting sustainability in the agricultural sector which means, for example (Feenstra, 2018; Barros de Mendonca & Laques, 2017; Mendonca, 2016):

- producing more in less space;
- lowering costs for farmers;
- lowering the negative impacts on the environment and respecting its limits;
- lowering carbon emission;
- increasing the profitability of producers;
- generating employment resulting in positive social impacts;
- compliance with labor legislation; and
- respect for health and the well-being of workers and consumers.

When evaluating research related to production, it is not enough to assess production processes and outputs (resulted from performance analysis); instead, innovation impact assessment is the key point for identifying farmers, industries, and consumers satisfaction, and improving producer’s quality of life, their profitability and the effects on the environment, that is, goes beyond outcomes. Hence, a major goal of agricultural research organizations has been developing impact evaluation processes (Alston, Norton and Pardy, 1995).

The organizations (public, private or nongovernmental) are the way for materialization of policies, plans, programs, projects, processes and activities. Thereby, to verify whether the world walks to the sustainability direction, one of the most fundamental mechanism is to evaluate the impact of organizations policies, programs, projects, products, services and activities around the world. This mechanism can also be called assessment of corporate innovation, and if it is a research organization, the name can also be innovation impact assessment process. And assessment must consider *ex-ante* (in the sense of prevention and within the planning process) and *ex-post* analysis, as in toward correction direction of happened actions, respectively both evaluations focusing on the sustainability impacts and considering its continuous improvement - reducing negative effects and increasing the positive effects (Craig, 2002).

It is expected that the first step should be that the public organizations implement their sustainability policies, and sustainability integrated assessment process becomes a natural way for public governance and management. Then, it is awaited that soon future impact assessment systems, involving a broad spectrum of production systems and supply chains, can be more expanded if comparable with present organizations reality. By survival and institutional sustainability issues, research organizations, for example, year-by-year will be pushed to demonstrate their feasibility by the economic, social and environmental dimensions, by means of an integrated and transversal vision.

For many organizations, the sustainability reports or social responsibility reports have been a consequence of this process. Sustainability reports and Social Responsibility reports represent a track to demonstrate how an organization has been more or less sustainable by appraising the impact of its performance and results upon society, economy and environment. It is a way to reply pressures and demands of society as well as of institutions responsible for public auditing or superior courts of public accounts in matters related to the economic, social and environmental responsibilities of organizations that use public resources (Barros de Mendonca & Laques, 2017).

This context expounds a natural pressure towards public research organizations: they have to prove the economic and social (and in it is included technological, political and cultural dimensions) return of public investments, search for reaching SDGs related to their activities, transparency for supreme auditing institution of the country and to the society, which means demonstrate positive impacts of its outputs and outcomes. It is exposed that sustainable impacts are expected of the products of knowledge, technologies, processes and services of these public research organizations. It has been an inevitable trend for developed and developing countries to evaluate the impact of research on society. “Organisations that fund research are under increasing pressure to justify their expenditure and to demonstrate that research provides value to the community” (Grant, 2006).

Market and societal demands for increasingly conscious standards of social and environmental responsibility, coupled with the need for the profitability of those who produce, have pushed research organizations to be more effective in generating sustainable innovations. Therefore, these organizations need to have an impact assessment methodology capable of measuring the level of sustainability of their scientific production, as well as a way of maintaining accountability (Heckman, 2006).

3. The Importance of Assessing Innovation: by Considering the Impacts Approaches

3.1. An Overview of Innovation Concepts and Approaches

For Schumpeter (1983), innovation consists of a new material and force combination that discontinuously emerges, generating new goods that consumers are not used to, generating a new production method, opening a new market, conquering of a new supply of raw materials or semi-manufactured goods, or even breeding a new productive organization.

Based on a linear model, Schumpeter (1983) suggested a three-stage process: invention, innovation, and diffusion. He was much more concerned with the effects of creation than with its causes. This approach was typical before the 1950s, but many organizations continued in that way for many years and even decades, after that (Greenacre et al., 2012). From the 1970s to the 1990s a new phase of innovation theories based on technological changes arose: induced innovation, evolutionary approaches and path-dependent models (Ruttan, 2001). From the 1990s to the present, the innovation theories moved in varied directions based on a systemic reading, in a dynamic and complex environment and on non-linear processes (Greenacre et al., 2012).

The Oslo Manual (Insee, 2016) indicates some innovation categories: product innovation, process innovation, organizational innovation and marketing innovation. For Planing (2017) it is essential that an invention can arrive at the market, but this is not enough. A feedback loop and a close relationship with the needs and desires of society are also required and denote that innovation is important, while these factors will depend on the impact analysis, sustainability warranty and longevity. According to Chesbrough et al. (2006), the research process cannot be closed because of the speed and dynamics of information require that organizations to be open to interaction and innovation with partners.

Innovation comes from interactions within a collective of actors that allows the mobilization of different types of knowledge - scientific and non-scientific (Barret et al., 2018). Innovation based on wide social comprehension understands that society drives the economy and is interested in the environment, and thereby creates a link among all these components, including the sustainable development agenda. Social innovations represent new solutions for products, processes, services, technologies or models that simultaneously meet a social need (Pisano et al., 2015).

Brazilian law of innovation defines it as “introducing novelty or improvement in the productive or social environment that result in new products, processes or services” (Casa Civil/PR, 2004).

> “Innovation is the process of making changes to something established by introducing something new. As such, it can be radical or incremental, and it can be applied to products, processes or services and in any organization. It can happen at all levels in an organization, from management teams to departments and even to the level of the individual” (O’Sullivan, 2008).

Disruption innovation is another reading for innovation, which forecasts that when a new actor enters to the market and frontally beat on competitors, offering better products or services, the older ones will try to innovate to defend their businesses. Either they will win from a new competitor, by offering even better services or products with more competitiveness, or one of them will acquire him (Christensen et al., 2015).

Presently, open innovation has been the most modern trend for innovation approach, especially due to our complex and dynamic information world which requires other organizational design for innovation. Open innovation has been defined as “… the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively” (Chesbrough et al., 2006).

Besides challenges for solving complex questions related to patent, open innovation process faces a larger challenge, which is a high skill for managing dispersed virtual Research & Development (R&D) teams, because it is difficult to create team motivation, coordination and synergy with isolated researchers. Another critical observed gap is the necessity of creating holistic models for open innovation (Gassmann; Enkel and Chesbrough, 2010).

As can be seen, an innovation that represents the key role of research organizations is directly connected to the necessary systems of impact assessment. And to be considered a holistic and transdisciplinary perspective it would be important to consider the prism for innovation, namely, social innovations which means solutions (e.g.: technologies, products, services, processes) that meet social needs, with effective and positive impact to society, which promote social empowerment and can provide better quality of life. And when we talk about quality of life, we must necessarily consider the environmental dimension, where society is inserted (Pisano et al, 2015; Cato, 2009).

In the present day, integrating sustainability (through its social, ecological and economic dimensions) in innovation projects becomes an essential condition for attuning to markets and the demands of society (Brook and Pagnanelli, 2014; Hansen et al., 2009).

By analyzing the previous approach (Brook and Pagnanelli, 2014; Hansen et al., 2009), it is evident that today is inevitable that a research and innovation organization must insert the sustainability vision in all stages of innovation, from the stage of identifying the demands, passing through each step of internal processes, to the generation of technological solutions. The organization has to ensure that the entire production process and its products generate positive impacts on society, economy and the environment as well as minimize negative effects on the environment (Brook and Pagnanelli, 2014; Hansen et al., 2009).

It means that it becomes essential to create partial or intermediary impact assessment mechanisms throughout the innovation process, which will increase the probability of generating sustainable products and technologies in the final of the process.

Copenhagen Convention Bureau (CCB) has an enlightening approach to sustainability innovation:

> "Sustainability-driven innovation goes beyond designing green products and packaging. It entails improving business operations and processes to become more efficient, with a goal of dramatically reducing costs and waste. It is also about insulating a business from the risk of resource price shocks and shortages. Taken together, these enhancements can deliver business benefits that go far beyond the bottom line—whether it is improving your overall carbon footprint, enhancing your brand image or engaging your employees in a more profound way" (CCB, 2014).

Developing innovations that lead to better practices is necessary to increase strategies and actions to add value to supply chains, reinforcing sustainability chains, with technologies, products, processes and services permeated by creative designs and practice platforms supported by sustainability vision and attitudes. Nevertheless, it will demand new business models and new institutional arrangements and dynamic way of work. New practices often require new paradigm and desertion of ongoing practices that will happen when decision-makers recognize a simple truth: "Sustainability = Innovation" (Nidumolu et al., 2009). It means that the innovation processes to be effective and meet the current requirements of society have to be impregnated by the principles of sustainability, permeating each step of the innovation (Nidumolu et al., 2009).

It is not more viable economic, social or environmental innovation by dissociating them along the process of knowledge construction. For impact assessment systems, approaches should follow the same way, which means, sustainability approaches by the cross-cut view of transdisciplinary, holism and constructivism concepts, not separating social innovation or economic or environmental innovation.

The innovation process in a research organization represents the steps that connect input, processing and output with technological solutions resulted from the research. The input should represent as accurately as possible the explicit or implicit demands of society and the economy, as well as the needs that the environment requires for its resilience. The evaluation process must follow the whole step of innovation, propitiating the assessment pathway on the innovation pathway, as a strategy of guarantee that solutions will be in accordance with what was planned (this phase can generate an *ex-ante* evaluation). However, this is not enough; it is necessary to make an *ex-post* evaluation of what was generated by the organization and verify the impact of this on the economy, society and environment.

Innovation is the process of generating and absorbing solutions. Impact assessment is the verification between what was expected to impact (*ex-ante* evaluation) and what has been impacted after outputs are absorbed by productive sector and society (*ex-post* impact), referred to agricultural technologies that were adopted in agricultural production, for example. Impacts have short, medium and long-term effects on the environmental, social and economic dimensions which must be assessed (Douthwaite, 2003; Hearn and Buffardi, 2016).

These impacts have to consider multiple spatial scales, since local or within the farm that adopted the agricultural technology, to the municipality where the farm is located, the state, the country and its reflexes on the planet (an exported agricultural product, for instance, will generate impacts on the importing countries, it implicates the carbon emission along the value chain) (Douthwaite, 2003; Joly et al., 2016; Hearn and Buffardi, 2016).

All these approaches and theories related to innovation contribute in some way towards a better understanding of impact evaluation concepts and processes and also help us to deepen the analysis and discussion, as well as draw constructive results on a more effective model of impact evaluation for a research organization. The view in favor of creating an overlap between innovation systems and impact evaluation systems is included in this context, as this is an important approach to a whole system that integrates and synchronizes both systems.

The United Nations Johannesburg Meeting established the basis for the Rio+20 Summit document and reaffirmed that sustainable development is a process that must consider a whole, inseparable and integrated approach without fragmentation among environmental, social and economic dimensions, which will require a broader range of participation from all social sectors. The innovation process must follow this principle (UN, 2010).

3.2. Impact Assessment Definitions

According to Oxford Dictionary (2018): 'Impact' can be understood as "the action of one object coming forcibly into contact with another; or a marked effect or influence"; or the effect on someone or something provoked by one or more actions.

For the United Nations Development Group – UNDG - assessment is an evaluation, "as systematic and impartial as possible, of an activity, project, program, strategy, policy, topic, theme, sector, operational area, institutional performance, etc." It has to focus on the examination of accomplished results or goals not reached, analyzing and identifying process failures (UNDG, 2011). "An evaluation should provide evidence-based information that is credible, reliable and useful, enabling the timely incorporation of findings," and generates recommendations and input for organizational decision-making processes (UNDG, 2011).

Based on the theory of changes, an evaluation process requires analyzing the results chain, which will be influenced by a set of economic, social, environmental, political or cultural aspects and their complex interactions as well as all the context, needs, priorities and aspirations of stakeholders, especially the key actors expectations (UNDG, 2011).

The results chain denotes the process which includes inputs to activities that produce their outputs with consequent outcomes and impacts; these results chain generate intermediate impacts up to the final impacts along the time, creating the framework of impacts which is named by CGIAR as impact pathway. "'Change' refers to any event or variation in the state of affairs. Change may happen at any point in time or place and may or may not be causally related to an intervention" (Brian and Palenberg, 2018).

The impact can be defined according to the institution, area of interest, expertise or performance. If it is a company, the focus will be the economic return on investment; if it is an environmentalist NGO, the focus will be an environmental impact; if it is a research organization, the focus will be the research impact (Hearn and Buffardi, 2016).

The scope of impact definition will set the length, intensity, and effect on the time, the reasons and its limits. Who is defining the impact and how will it be analyzed and judged? What kinds of values are embedded in the impact analysis and its purposes? These questions should be more stressed (Hearn and Buffardi, 2016).

For the USAID[2] impact results of a specific program. White (2010) says that impact requires a specific definition which involves comparison with counterfactual: what would have happened in the absence of the program or project?

[2] United States Agency for International Development

The UNAIDS[3] considers that impacts at a population level are rarely attributable to a single program or intervention. The impact has different dimensions adaptably to its definition and way of interventions: “including the direction, subject and level of change, degrees of separation, timescale, rate and durability of change and homogeneity of benefits” (Hearn and Buffardi, 2016). This means that often the impacts of a innovation project can become diffuse, both in its identification and in its causes, generally being a consequence of the intervention or contribution of several agents and not just an actor or research institution.

For some organizations or approaches, often, impact and outcomes get in confusing settings and end up overlapping regarding the meaning. They can create convergence or even conceptual misunderstands. Groups and organizations usually create their own concepts about them. CIFOR[4] understands outcomes as changes in behavior and institutions resulting from changes in knowledge, attitudes, skills and relationships. The impact is qualitatively different, defined as “change in flow” or a “change in state,” referring to parameters such as income, poverty status, carbon flows or forest condition (Brian and Palenberg, 2018).

In the context of impact evaluation, according to the Organisation for Economic Co-operation and Development – Development Assistance Committee (OECD-DAC), the impact is conceptualized as “positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended” (OECD, 2002).

The European Commission understands that if an institution establishes a policy, it expects that its implementation generates impacts. “Such impacts may occur over different timescales, affect different actors and be relevant at different levels (local, regional, national and the European Union). In an evaluation context, impact refers to the changes associated with a particular intervention which occur over the longer term” (EC, 2017).

[3] United Nations Program for Combating AIDS

[4] Centre for International Forestry Research (CIFOR): The CIFOR is one of the CGIAR’s 15 international research centers.

The high quantity of terminologies, approaches and analyses on impact evaluation results in the dispersion and disintegration of understanding on this issue. They are biodiversity impact assessment; climate change impact assessment; economic evaluation; environmental impact assessment; environmental, social and health impact evaluation; integrated impact assessment; social impact assessment; strategic environmental evaluation and sustainability assessment which represent just some of a long list of approaches to impact evaluation, that indicates how large the scope of this issue has been (Pope et al., 2004).

Recently, some approaches and systems for impact evaluation have been published, such as social, environmental, technological, economic and fiscal impact assessments (Becker, 2001), as well as health impact assessment (Wernham, 2011). According to Reale et al. (2017), it is important to analyze different impact methods as scientific, dissemination, political and social impact, stressing that the latter must be understood as having a higher priority than others.

Environmental reports have been printed as documentation of accountability, as a means of transparency for stakeholders and as a publication of social and environmental responsibility for society, e.g., the Sustainability Report based on GRI – Global Report Initiative (GRI, 2017).

However, the above list could be completed by the addition of a research impact assessment - RIA. According to the International School on Research Impact Assessment, the importance of research impact assessment is growing, and research organizations must meet the requirements of donors who invest in research and expect economic and social returns (ISRIA, 2017).

For years, RIA required the time of many researchers and analysts aiming to answer, with consistent data, the feasibility of research regarding its economic and social impact. Over the past 50 years, several papers have been published to analyze the impact of agricultural research and how it has generated positive effects on the productivity of farmers and the supply chain in the agribusiness sector and produced relevant returns on applied investments in Research & Development (Alston, 2010).

"There is a distinction between 'academic impact' understood as the intellectual contribution to one's field of study within academia and 'external socio-economic impact' beyond academia" (Penfield et al., 2014).

Many organizations have adopted several ways to evaluate their research impacts, including in the agricultural field, for instance, the Consultative Group for International Agricultural Research (CGIAR), the Brazilian Agricultural Research Corporation (EMBRAPA, 2015), the Economic Research Service (ERS) of the United States Department of Agriculture (USDA) and the Commonwealth Scientific and Industrial Research Organization for Australian Research - CSIRO (Joly, P. et al., 2016).

Driven by productive systems demands, competitiveness for innovation and government rules for the efficient use of public resources normally imposed by financial resource restrictions, many countries have developed systems for impact evaluation (Ruegg & Feller, 2003). Currently, it is not enough to elaborate policies and programs without evaluating impacts as a way of effective governance and a means of ensuring consistency between plans and resource application. At the same time, it is not enough to assess only economic and social impacts or to keep the environmental agenda restricted to intentions, papers or sterile policies (Barros de Mendonca & Laques, 2017).

Integrated evaluation is defined as "an interdisciplinary process of synthesizing, interpreting and communicating knowledge from diverse scientific disciplines to provide relevant information to policy-makers on a specific decision problem" (EEA, 2001). The real sense of the sustainable evaluation process is to ensure that policies, strategies and operational actions contribute to sustainable development (Verheem, 2002).

In 2015, the European Union founded the Impact Assessment Institute to analyze and assess its policies, covering all processes of policy from formulation to implementation and consequent impacts, monitored by *ex-ante* and *ex-post* appraisal (IAI, 2017).

The European Commission has developed a renewed set of guidelines on impact assessment, as part of its regulatory agenda for evaluating policies. They created *ex-ante* and *ex-post* assessment by separating both in individual systems. Indeed, it is not coherent with the principle of cycles of policy that would recommend both joined systems into one managerial system for policies that could facilitate to link both systems and create a sequence of events within an analytical logic, although that effort is an important reference regarding two systems to evaluate policies' impacts. (Mergaert and Minto, 2015).

More recently, the European Commission has been discussing a new approach to impact assessment: innovation impact assessment, initially discussed at the universities context, but opening up the discussion to a broader scope, involving any public or research institution, for example (Jonkers et al., 2018).

The proposal is that teaching and research cannot be parked at the output level. It must go further, reach the level of outcomes that is, actually, become one or more innovations, which are appropriate outputs or adopted by users and customers. However, it is not enough to be restricted to the evaluation of the outcomes, it is necessary to arrive at the level of impact evaluation applied on their outcomes, in the social, economic and environmental fields. It is necessary to show transparency and trustworthiness where public resources or financers funds are impacting in the concrete world and over time (Jonkers et al., 2018).

As we dive deeper into the discussion on impact assessment, it is inevitable to understand the impact pathway and to carry out an evaluation process on its track while demonstrating their stages step-by-step, which offers an essential view and makes accurate analysis and captures optimized feedbacks. The pathway used by Douthwaite et al. (2003) creates the theoretical base for evaluating *ex-ante* (as planning phase) and *ex-post* (as post-outcome phase).

Based on this pathway, it is important that the evaluation process considers the *ex-ante* and *ex-post* phases in the analysis. The planning phase means prevention (*ex-ante* impacts), and the post outcome (*ex-post* impacts) phase represents a mechanism for feedback and orients towards the correction of the planning phase. The outcome phase must be evaluated some years after the project has been finished because its effects or impacts happen over the long run (Barros de Mendonça & Laques, 2017).

By looking at Figure 1 below, it is possible to identify a template that represents a general model of innovation impact assessment, which will serve as the basis for the new and future model to be drawn in Part III of this thesis. The figure was adapted from Kuby's (1999) scheme and Dowthwaite's approach (2003) and it demonstrates a complete systemic vision of impact assessment from the planning phase to the effect phase, which means the stages after an organization produces its technologies and their absorption by producers and clients as well as its immediate consequences to the economic, social and ecological environment.

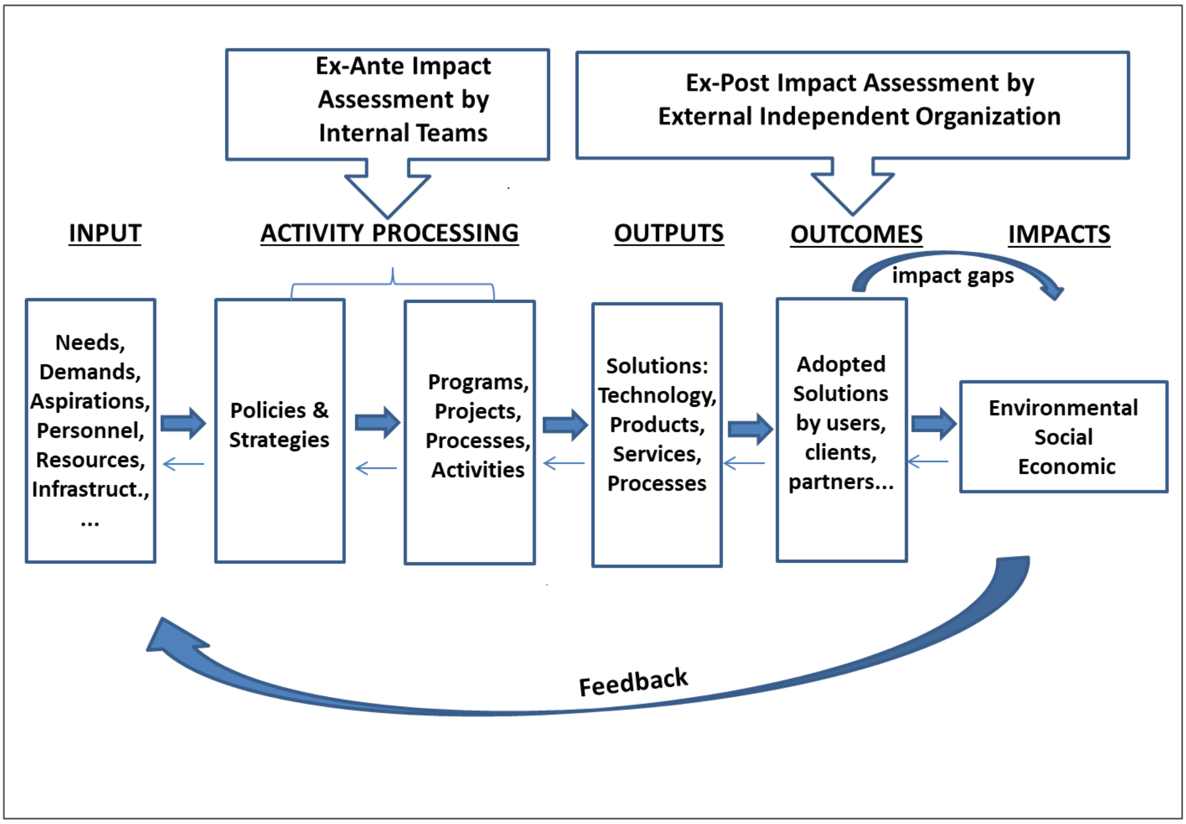


Figure 1. General Model of Impacts Pathway (Adapted from GTZ Impact Model - Kuby, 1999)

In addition, the effect phase considers the long-term impacts on the economy, society and environment, which could be named as impact gaps and lagged impacts because it is difficult to determinate when impacts will happen and whether they will generate simple or complex, direct or indirect effects. Indeed, immediately after the output phase, it will be possible to identify impact gaps and lagged impacts because one new technology, for instance, may take a long time to be disseminated, understood and used by farmers, as well as engender an impact on the society, economy and environment.

By analyzing Cato's approach (2009), it is also possible to observe that the economy and society generate demands due to the needs and yearnings induced by them, and these feed the innovation process. Ecology has essential needs for its resilience. All these environment inputs will orient public policy and organizational strategic planning. Policies and strategies will provide a governance framework and managerial bases for defining priorities and establishing strategic processes, programs, projects and activities that will produce outputs or solutions regarding technologies that will be transformed in outcomes or innovations when they have been adopted or appropriated by users or clients.

These innovations will cause negative or positive and direct or indirect impacts on the economy, society and environment in the short, mid or long-term. Direct and first impacts will affect the clients closest to the organization that has developed the innovation.

4. The Need of a Conceptual Model on which to Conduct an Impact Assessment

4.1. Conceptualizing System, Model and Conceptual Model

As the proposal of this thesis is to create a conceptual model of impact assessment management system of innovation, it becomes necessary to explain "what a system, model and conceptual model are" in this thesis scope.

The system can be defined as a set of components that interconnect and interrelate with each other, so that their parts form a whole and this interaction provides some logical purpose, generating final effects over a certain time, with some regularity, forming a network of causes and effects. These components can be objects, equipment, information, people or even other systems, that is, subsystems. These components can be either fixed or transient. The system has boundaries, and both, its internal and external part is called the system's environment (Metherbe, 1986; Law and Kelton, 1991; Buckley, 1976).

> "A system may be defined as a set of elements standing in interrelation among themselves and with the environment. There exist models, principles and laws that apply to generalized systems or their subclasses, irrespective of their particular kind, the nature of their component elements and the relation or 'forces' between them" (Bertalanffy, 1968).

General system theory is a useful tool, providing, on the one hand, models that can be used and transferred to different fields, and safeguarding, on the other hand, vague analogies that may affect or change the operation or evolution in those fields. This approach concerns the concept of isomorphisms, which presupposes that a general model of one system can be applied to different phenomena. Thus, it can be applied to biological, behavioral and social sciences. It is a solution especially applicable to approaches involving a multiplicity of disciplines, given its strength of convergence, integral comprehension and transversality (Weckowicz, 1989).

Conventional physics, until recently, dealt only with closed systems, that is, systems that are considered isolated from their environment. However, there are systems that, by their very nature and definition, are not closed. Every living organism, for example, is an open system. It remains in a continuous entry and exit, an accumulation and decomposition of components, and, while it is alive, will have a thermodynamic equilibrium, with a certain degree of stability, but at the same time, having a certain level of dynamism (Bertalanffy, 1968).

In any closed system, the final state is determined by the initial conditions: for example, the motion in a planetary system where their positions determine the positions of the planets at a time. It does not work that way on open systems. In these, the same end state can be reached from different initial conditions and in different ways during operation. This process is called equifinality (Bertalanffy, 1968).

According to the second principle of thermodynamics, the general tendency of events in physical nature is for states of maximum disorder and leveling of differences, with the so-called thermal death of the universe as the final perspective, when all energy is dissipated. In contrast, the living world shows in embryonic development and evolution a transition to a higher order, heterogeneity and organization. Thus, based on the theory of open systems, the apparent contradiction between entropy (death of the system) and evolution disappears (Weckowicz, 1989).

Therefore, the change of entropy in closed systems is always positive; the order is continually destroyed. In open systems, however, we have not only the production of entropy due to irreversible processes, but also the import of entropy, which may be negative. It is the case of the living organism that imports complex molecules with high free energy content. In this way, living systems, remaining in a stable state, can prevent the increase of entropy and may even develop into higher order states and organization (Weckowicz, 1989).

Another point related to the theory of the system is that of the modern theory of communication, which is closely correlated with the flow of information, which, drawing a parallel with Physics, would be the flow of energy. In the field of organizations, this can be measured through the decision-making process, regarding the feedback that is connected to the input of the system (Bertalanffy, 1968).

The external environment of the system is observed, information is captured and treated and get into as input, as well as after the system generates its products, it will be essential to capture new information from the social, economic and ecological environment, such as feedback for decision making. This feedback will be basic to make adjustments in policies, plans, projects and actions aiming to promote system survival and sustainability (Markus et al., 2002; Calbo and Pusinhol, 2017).

By its general concept, when considering a system, one must consider that there is a general basic structure inherent in all systems, namely: environment, input, the process, output and impact on the environment (social, economic and ecological) resulted from what the system has produced. The process is composed of stages or intermediate steps that make the connection between the input and the output of the system. The system allows it to be represented by a model. The model is used to allow understanding the structure and how a system operates. It usually consists of the general structure of the system, its inputs and outputs or subsystems, as well as its components and their respective interrelationships (Buckley, 1976; Metherbe, 1986).

Derived from the vulgar Latin *modellus*, the term ‘model’ comes from the Italian *modellus*, which means modus or measure. Model is the ideal form, a reference that can generate other from it. A theoretical model is a hypothetical and theorized reference, which serves to analyze a concrete reality and uses as a baseline for application in the practical world or developing other ones (Japiassu and Marcondes, 1989).

There are situations in which the process may become more important than the structure of the system itself, since when dealing with social factors, it implicates that they are interacting with people who have thoughts and behaviors capable to result in unexpected decisions and attitudes which can generate changes in the process and, in turn, cause changes in the structure. The same can happen when it comes to a field that at any moment is subject to changes or process evolutions, as is the case of cybernetic or information technologies; or even in biological processes, when, for example, they involve viruses that are subject to self-mutation, causing unexpected changes in structure (Buckley, 1976; Geyer and Zouwen, 1992).

When analyzing concepts and methodologies in use of research impact assessment, it is fundamental to adopt, as a reference, the general theory of systems and how their principles apply in the verification of these approaches and how they will help in the construction of the new model of the evaluation system of impact. These points will be addressed in the future parts of this thesis.

This thesis is not intended to test a theoretical model in the real world but develops it from past and present theoretical approaches added to the comparative study of research organization experiences that adopt specific methodologies for assessing their research impacts. This argument justifies the elaboration of a conceptual model of an innovation impact assessment system, from a cross-cut perspective of sustainability.

Conceptual modeling is a representation of a general or detailed system that uses concepts and ideas to form the representation. Conceptual modeling is adopted in various fields of knowledge, from the exact sciences, biological or environmental, to the social and economic sciences and to software development. Thus, conceptual modeling is used as a way of explaining the physical or social framework and processes of the world in a theoretical way (Powell-Morse, 2017).

Figure 2 below presents a model of basic design to demonstrate the general theory of systems and their adaptation to the innovation process, and in the sequence, it will be the basis for each step through the impact pathway evaluation. Therefore, input, processing and output, and their consequences, that is, the impacts, structure a whole system that denotes the most basic model of the innovation process coupled with the impact assessment process. It is the general logic which will support the model to be constructed in this thesis.

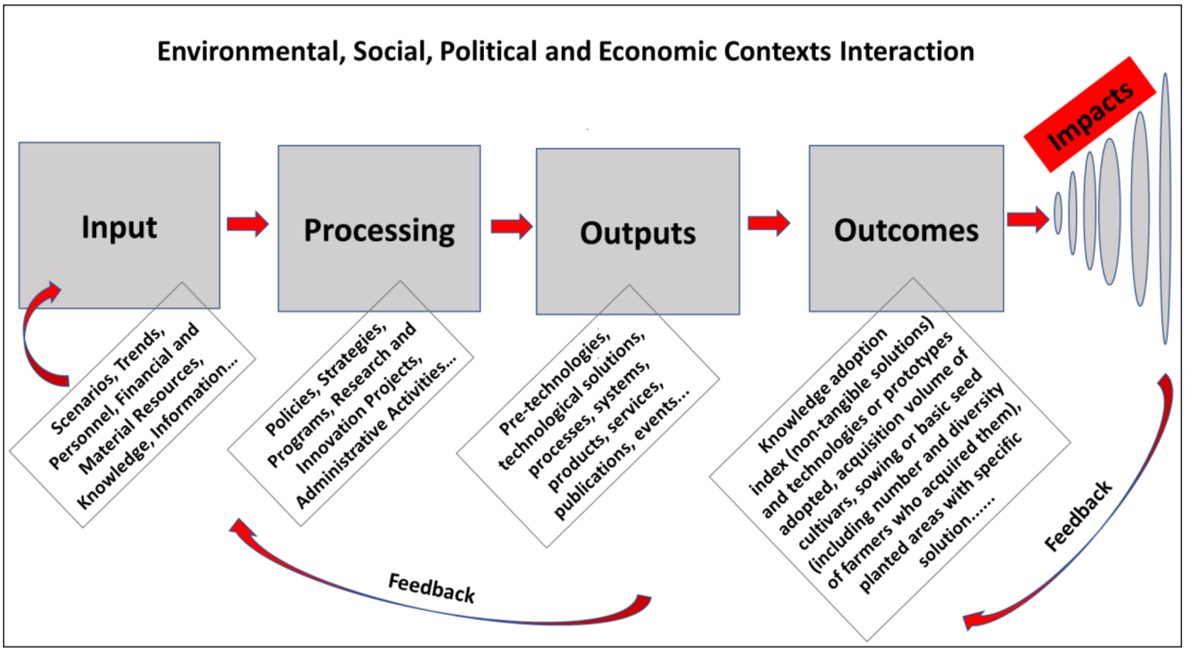


Figure 2. Innovation Architecture Based on General Theory of Systems

Input are all needed elements to the functioning of the research organization (scenarios, trends, personnel, knowledge externally absorbed and inherent of its internal teams, financial resources, material resources and all kind of infrastructure and information that feed the organization).

All the elements absorbed by the input phase will be processed and will generate policies, strategies, research programs or portfolios of projects, administrative processes and all internal activities, which will demand continuous interrelationship with the external environment.

Outputs represent every product generated by the organization, that, in the case of an agricultural research institution, will be pre-technologies, technological solutions, services, processes, publications and so on. Outcomes will be the following phase that represents results adopted by the users or clients, which represent the key moment or the apex of the innovation. Finally comes the impacts phase on the environment, society and economy.

4.2. The General Bases to the Framework of an Impact Assessment Model

The general framework of an innovation impact assessment model should take into account three key contexts: structural (with four components), innovation and behavioral (with three components). These three contexts must be well defined and serve as the conceptual basis for structuring the model, an essential condition for its success.

4.2.1. The Structural Context

The role of innovation impact assessment structural context means to identify and define its four assessment dimensions (economic, social, political/policy and environmental), which will compose the concrete structure of the impact assessment of innovation. In other words, this topic will clarify the diversity or kind of assessment and its approaches, as described in detail nextly:

<u>Economic Assessment (EA)</u>

Economic impacts have different levels of economic effects of an organization's activities in a given area and supply chain. It can be identified by measuring: I. Business outcome or products and services acquired; II. Value-added (or gross local, regional or national product); III. Wealth (including property values); IV. Personal incomes (including wages); and V. Jobs (Weisbrod and Weisbrod, 1997).

The economic assessment, which forms part of the social impact assessment, in turn, aims to examine all aspects that might contribute for the gain or loss of individual, community, regional or national resources. Many of the underlying causes of economic effects like perception, opinion, and feeling cannot be quantified, and therefore qualitative data have to be used to support conclusions in the EA. An economic impact will quantify the economic value to a local, regional and state economy, including the value of production, jobs by sector, jobs by income level and tax revenue generated (MasterQResearch, 2012).

Economic impacts assessment of an organization can be analyzed by verifying direct impact, indirect impact and induced impact. The first one is the economic benefit resulted from all activities and products generated by the organization. The second one implies the economic benefit and employment generated to the connected supply chain to the products and services produced by the organization. The third one represents the benefits that arise when employees of the organization and its supply chain spend their earnings, locally or anywhere (Oxford Economics, 2013).

The catalytic economic impact is a relatively new concept that shows long-term effects on other different productive chains or organizations or other sectors of the economy. It also could be defined as all other benefits associated with different sectors of society that especially related to social and human capacity building, which will allow positive impacts to the organization outputs and outcomes, as consumption access of good and services and improving quality of life (Oxford Economics, 2013).

Inspired on the trend of international agricultural research, Alston, Norton and Pardy (1995) say that impact assessment processes are supported by two factors:

- to afford information to managers of public research institution and scientists about how technology affects farmers and consumers (also offering evaluation reports for better decision-making towards necessary adjustments in research programs guidelines and resource allocation); and
- to supply consistent data and information for stakeholders (governments and partners) on positive social impacts resulted from their investments in research.

Environmental Assessment

The International Assessment Impact Association – IAIA defines impact assessment as a process which can identify the future consequences of any type of a proposed or current policy, project or action (Huge and Wass, 2011). Based on the first concept of environmental impact assessment defined by NEPA (National Environmental Policy Act – it was the first major environmental law in the United States), added by several global discussions in the UN conventions and international meetings, the United Nations Environment Programme - UNEP defined Environment Impact Assessment - EIA as an instrument for identifying environmental, social and economic impacts of a specific project which must be elaborated before its decision for design and implementation (UNEP, 2004).

It has to prevent environmental impacts and identify ways and means to avoid or reduce negative impacts, proposing alternatives for the decision-making process. By elaborating on EIA, laws and regulations must be followed and aimed at a balance between economic optimization and environmental impact minimization (UNEP, 2004).

ISO 14001 defines environmental impact by its international standard as:

> "Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's environmental aspects, where environmental aspect is defined by the element of an organization's activities, products or services that can interact with the environment" (ISO, 2015).

Convention on Biological Diversity – CBD (2006) defines EIA as a process of assessing possible environmental impacts of a proposed project or development initiative, considering socio-economic, cultural and human-health impacts, by taking into account all that dimensions that are interconnected, identifying both positive and negative effects.

According to Sadler and Verheem (1996):

> “Strategic Environment Assessment (SEA) is conceptualizing as the formalized, systematic and comprehensive process of identifying and evaluating the environmental consequences of proposed policies, plans or programs to ensure that they are fully included and appropriately addressed at the earliest possible stage of decision-making on a par with economic and social considerations”.

According to FAO (2012):

> “EIA is a tool for decision-makers to identify potential environmental impacts of proposed projects, to evaluate alternative approaches, and to design and incorporate appropriate prevention, mitigation, management and monitoring measures. Environmental impact assessment cannot be divorced from the social impact of the project…”.

For helping organizations to identify, manage, monitor and control the environmental impacts related to its activities it is fundamental to construct environmental management system, especially using an integrated approach with a holistic perspective (ISO, 2014). Towards this vision, ISO sets the voluntary norm ISO 14001 centered on orientating how organizations can implement an environmental management system, gradually. As a consequence of that, ISO created the Life Cycle Sustainability Assessment (LCSA) ISO 14040 norm, as a voluntary standardization aiming to be adopted *ex-ante* of implementing projects and activities.

Social Assessment

By Becker and Vanclay (2003) concept, Social Impact Assessment (SIA) is “the process of identifying the future consequences of a current or proposed action which are related to individuals, organizations and social macro-systems.” To Vanclay, social impact is “the process of analyzing and managing the intended and unintended consequences of planned interventions on people to bring about a more sustainable and equitable biophysical and human environment." By considering SIA understood as a continuous process, not limited by technical practices, it is complicated to set limits (Becker and Vanclay, 2003).

The current tendency has being to connect the economic with social assessment as part of impact studies. Then, it can be considered as socio-economic impact assessment (SEIA) as just one approach. It also is important to consider that the traditional environment impact assessment analysis has seen to include the socio-economic studies into the EIA approaches. In this case, SEIA intends to identify and evaluate the potential socio-economic and cultural impacts of a proposed development project on the lives and circumstances of people, their families and their communities. "If such potential impacts are significant and adverse, SEIA can assist the developer, and other parties to the EIA process, find ways to reduce, remove or prevent these impacts from happening" (The Review Board, 2007).

Political and Policy Assessment

Primarily, it is important to define policy and politic ('political' is an adjective derived from the 'noun' politic), and what concept will be emphasized in this topic. According to Oxford Dictionary (2018), the word **political** is related to the government or public affairs of a country, for example: 'a period of political and economic stability'; 'a decision taken for purely political reasons.' By the other hand, the **policy** means "a course or principle of action adopted or proposed by an organization or individual," for example: 'the government's controversial economic policies.'

Political science consists of studying the process by which the societies organize and are regularized, from a perspective of governance. The political process usually uses public policy to govern. It can also be said whether a private organization has its process of organizational politics and also uses the policies in the form of strategies and guidelines for its governance and management process (Birkland, 2016).

This thesis and specifically this topic consider both terms: political and policy evaluation by dissecting each one according to the situation and involved framework and process along the innovation and assessment courses. Governmental and organizational policies related to the research and innovation should equally evaluate the political process that can drive those policies to reach efficacy and effectiveness: the first one represents the instruments (policies), and the second represents the process (political) while way for reaching good results of the policies. For positive impacts of the policies, it is necessary political skills.

The European Commission has, perhaps, the most relevant knowledge experience on impact assessment oriented for public policies. Impact assessment according to its guideline, is defined as “a set of logical steps to be followed when you prepare policy proposals” (EC, 2019). It is an *ex-ante* impact evaluation process for helping decision-makers about the potential impacts of each policy proposed, which is presented by a specific report.

An important way for elaborating and implementing policy is to create mobilization, engagement and commitment during a political process, developing collaborative governance, which means a high level of actors or stakeholders’ participation from the beginning of the process up to its evaluation stage. The policy value is outside of government; it is sustained by the clients, partners and external people from the organization that is directly or indirectly affected from that policy or organizational initiative or during the political process (Donahue, 2004; Ansell and Gash, 2007).

Collaborative governance can be defined as a wide set of processes and structures of public policy decision making and management that engage people by a constructive way running through the limits of public agencies, levels of government, and the public, private and civic sectors to implement a public purpose that could not otherwise be achieved (Emerson, Nabatchi and Balogh, 2011).

This item seeks not only to conceptualize what is policy and politics but to outline some essential requirements so that they are successful in their elaborations and implementations. These concepts induce us to understand that collaborative governance is an essential way of constructing a well-based innovation process and creates conditions for positive future impacts *ex-post* or after the policy has been implemented. Beyond the *ex-post* evaluation, it is important an *ex-ante* impact analysis as a simulation process to identify negative and positive possible effects of that policy. This *ex-ante* analysis can consider collaborative governance as part of its political strategy aiming to generate successful impacts (Emerson, Nabatchi and Balogh, 2011).

Currently, the reality has shown that a single entity is incapable of individual success in constructing and implementing policies or driving a political process, building knowledge, developing technologies, reaching efficacy of managing conflict, or in project implementation processes by a multi-dimensional environment (Orth and Cheng, 2018).

4.2.2. The Innovation Context

A simplified model of innovation assessment should include at least four main cognitive processes, which strongly influence the evaluation process: formation of assessment criteria, formation of expectations about the innovative concept, assessment of satisfaction with an old product and comparison the new with the old products (Olshavsky and Spreng, 1996).

Often, when confronted with a highly innovative concept, the consumers may find it difficult to characterize their own evaluation criteria and expectations about this innovation. This reality opens the opportunity for the managers of the organization that generated the innovation, educate the consumer on the appropriate assessment criteria, or communicate the appropriate attributes, benefits and resources of the new product or service (Olshavsky and Spreng, 1996).

“The peculiarities of service innovation require a wider approach than that observed for goods innovation, which is less focused on non-technological aspects” (Gago & Rubalcaba, 2007). This means that in order to assess service impacts, a wider and more flexible approach is required than the evaluation of outcomes of products or technologies, which have more concrete and quantifiable characteristics (Gago & Rubalcaba, 2007).

Research organizations deliver technologies and products, but must also deliver services, such as technology transfer services and other services (such as publication generation, field days, lectures and other events of diffusion) as essential instruments capable of enabling the adoption of technologies that will generate impacts to the productive sector and consequent effects in the economic, social and environmental dimensions.

It is recommendable that the impacts of services linked to innovation should be examined by the execution of probabilistic and sample selection models. The results indicate a certain correspondence between the multidimensional nature of service innovation and impact assessment. This framework proves that the innovation process is broad and complex enough to require constant interaction with stakeholders, in all its phases, and also requires, by teams of different specialties and members of the various partner organizations, clients or users and even those who receive unintentional impacts of the innovations generated - and must be integrated along the innovation process (Gago & Rubalcaba, 2007).

Whether it is a private or public research organization, it needs to build and evaluate its policies, plans and innovation projects responsibly, by interacting these processes with external actors, monitoring and being aware of the needs and demands of those who represent society. This context induces an impact assessment model supported by a dynamic, flexible and efficient innovation process (von Schomberg, 2012; Greenacre et al, 2012; Chesbrough et al, 2006).

The intention of research organizations to seek to meet societal needs has an attractive bias, but, in general, impact assessment systems do not show how the various segments of society with many competing and diverse interests can reach consensus, and how this context could guide public research policy. "Scientists funded by public funds have the moral and political obligation to consider the broader effects of their research" (von Schomberg, 2012).

Creating collective co-responsibility is an essential practice to achieve harmony with social interests and social responsibility. For this, the process of characterizing and constructing innovation solutions and its impact evaluation must start from public discussions, with representative teams of society, including, at least, research financiers, members of productive chains, representatives of governments, representatives of sectors concerned and responsible for environmental protection and consumers (von Schomberg, 2012).

When carrying out a process of innovation evaluation it is necessary to be careful to the fact that there is a social, economic and environmental dynamics in the world and specifically in the environment where the previous innovation occurred, as well as its impacts in the environment where it operates at the moment. In this way, it becomes fundamental to develop a comparative analysis between an old or ongoing innovation with a new one that has reached the market, taking into account the several variables of a marketplace, cultural, economic and environmental nature, before making a precipitate analysis (Walker, 2007).

Both the innovation process and the innovation assessment process should be as participatory as possible. The generation of new solutions to solve problems, expectations or challenges in the social, economic and ecological environmental requires interactions with stakeholders directly and indirectly linked to such problems, challenges or expectations, not only because they are more interested in the solution, but because they bring their knowledge and experiences, which must be considered in the same degree of importance as the knowledge inherent to the scientific body (Diez, 2001).

The trend is increasingly enriching the innovation process with the participation of interdisciplinary teams, networks of experts, scientists and also groups located in the practical world (on the 'factory floor'), including the leaders involved in these processes (Diez, 2001).

Considering that the innovation generation should be market-based, whatever the assessment process of innovation is, it must be based on the external environment of the organization, that is, the participation of the customer and all stakeholders in the evaluation is an essential condition of its success. This success is based on the trustworthiness of the data and information collected, understanding that the market extends throughout the supply chain of the product or service added to the innovation (Georghiou et al, 2003).

Four categories of elements are fundamental to carry out an innovation impact assessment model under the sustainability bias:

a) organization (a proto-model with a general framework);

b) internal processes (assessment stages along the innovation process – from the stakeholders demand and needs characterization to outcomes and impacts steps);

c) functions (component definitions and how they will operate), and

d) tools (instruments for capturing data and information from users, clients, investors/funders and environment, during *ex-ante* and *ex-post* evaluation).

It is believed that incorporating these key elements into the processes of product and technological innovation will encourage the organization to have a strategic perspective of sustainability that will support its long-term success (Hallsted; Thompson and Lindahl, 2013).

Innovations generate global or final impacts. Although most research and innovation organizations focus their impact assessment models on the final results, that is, conducting the *ex-post* evaluation, it is paramount to evaluate the intermediate impacts, which means, to carry out evaluation along the way of innovation process as an essential step towards achieving positive results at the end. This intermediate assessment of impacts, or evaluation of the course of innovation, should not lose sight of what was conceived as final impact goals, which will guide the entire innovation pathway. It should be emphasized that the predicted goals of innovation impact should be elaborated in the planning stage of research and innovation, in what is usually called *ex-ante* impact assessment (Dalziel & Parjanen, 2012).

An innovation impact assessment model has to consider the evaluation of its own process and its consequent final products; all the time taking into account the market, environmental and social responsibilities (Planing, 2017). The model must create a wide interaction within a collective of actors, mobilizing different types of knowledge - scientific and non-scientific, towards social needs (Barret et al., 2018; Pisano et al. 2015).

The innovation model must be superposed and interconnected with the impact assessment model and both have to propitiate disruption innovation, breaking paradigms, or simply small but important innovative methods, systems, processes or practices, which will demand the holistic approach (Christensen et al., 2015; Gassmann et al., 2010).

4.2.3. Behavioral Context

The behavioral context is composed of four components: holism; transdisciplinarity; constructivism and management approach.

This item is called a behavioral context due to factors that involve aspects related to human, individual and social behavior, and its reflexes in the processes of research and innovation and evaluation of the impact of innovation. Managing a research organization, innovation projects and impact assessment processes effectively involve not only "cold" issues of management structures and processes, but of human behavior, which requires the adoption of theories and approaches that deal with these issues. After all, it is inevitable to deal with human beings, work teams and social environments with their various complexities, games of interest, vanities, self-protection and other behavioral issues (Jonkers et al., 2018).

For UNICEF, social mobilization “is a process that engages and motivates a wide range of partners and allies at national and local levels to raise awareness of demand for a particular development objective through dialogue” (Unicef, 2015). All change process linked to new technology, new project, policy or social intervention will demand social mobilization (Rogers, Goldstein, and Fox, 2018). Engagement is as a positive and satisfactory state of mind. It means a state of a high level of energy and resilience; enthusiasm and concentration in the activity where a person or a group are involved (Bakker et al., 2005). In an open innovation process, it is noticeable that engagement is essential for outcomes and the impact to be reached (IM, 2013).

Governing and integrating a team of innovation management and research impact management is not for amateurs, nor can it be improvised with researchers and technicians who are not qualified for this role: it requires a series of attributes and appropriate knowledge and skill in social mobilization and stakeholders’ engagement, while will require well qualified transdisciplinary teams, that will, in turn, require emotional intelligence. Emotional intelligence is “something” in each of us that is a bit intangible. It affects how we manage behavior, navigates social complexities and makes personal decisions to achieve positive results” (Bradberry, 2018).

Innovation and impact assessment processes imply involving clients, partners, financers, diversified interest groups and individualities, which means people’s involvement, which requires the capability for social mobilization and engagement and behavioral skills. Due to the nature of transversality and the integrated approach to impact assessment, it is essential to insert some approaches which are defined in this thesis as ‘social and behavioral context’ to create a well-based structuring of the conceptual model of impact assessment here developed. As following: holism, transdisciplinarity, constructivism, and management approach which will meet analyzes of the process of conflicts management and its relationship with leadership and engagement.

Holism

Holism was firstly defined in 1926 by the South-African Jan Smuts. He said: "the whole is more than the sum of its parts. The entire universe was based on an innate tendency for stable wholes to form from parts" (Gatherer, 2010). Against reductionist approaches, the holistic approach implies to see complex systems based on an ensemble of hierarchies from the macro level to the nano level, from the universe to subatomic particles. "For a cell biologist, holism might mean thinking about the whole liver." Depending on the context it might mean the "whole person, the whole community, the whole of society, or the whole planet." Then the scale will define your context to apply the holism concept (Freeman, Joshua, 2005). Human behavior is "based on one-sided/biased thinking resulting from reductionism and over-specialization, causing critical oversights: many specialists do not feel and apply ethics of interdependence by interdisciplinary approach" (Mulej et al., 2006).

There is a strong convergence between holism and inter- or transdisciplinarity concepts. The second revolution of systemic sciences succeeded and complemented the first by rearranging disciplines around the complex interactions of objects known as systems (Morin & Le Moigne, 2003).

Transdisciplinarity

Before beginning the approach on transdisciplinarity, we will understand disciplinarity and interdisciplinarity.

Disciplinarity can be understood as a category to scientific knowledge organization, dividing it through typical specialization. Although each specialization is set into a wide scientific grouping, due to its border, each discipline tends to reach its autonomy by its theories, techniques and languages. This approach focused on the (mono) disciplinarity, especially from the 1950s, does not refuse classical science and also does not compete with it (Morin, 1990).

The unique specialization or disciplinarity approach is exhausted. The world has been evolving towards a new dynamic of life that requires not only new discuss on multidisciplinarity but, new attitudes towards transdisciplinarity. Recently cross-cut vision and integrative behavior have been required for business management as well as for academy, science & innovation. The science results will be more effective from an integrative approach (Roquete et al., 2012).

According to Piaget (1972) approach of interdisciplinarity, it represents a cooperative process resulted from real reciprocities among people (scientists, specialists, technicians or professionals) and mutual enrichment. Science is developing in new directions those cross-traditional disciplinary boundaries to such a degree that disciplinary silos can become obstructions. Transdisciplinary research is a new trend for knowledge construction (Cohen and Lloyd, 2014).

In the information or knowledge society, there is a need for transdisciplinary research, i.e., research that deals with complex life-world problems. Transdisciplinary projects aim to come up with practice-oriented solutions that serve to what is perceived to be the common good (Hadorn and Pohl, 2007). "Transdisciplinarity is a principle for organizing processes of mutual learning and problem solving between science and society. Thus, transdisciplinarity may contribute to sustainable development" (Scholz et al., 2000). For Caon (1998), transdisciplinarity is focused on the team and how it will solve a problem or challenge. Each team member enters into the discipline of their colleagues and all look through one another's eyes (as in an exercise of empathy). Transdisciplinarity focuses on the interaction between the disciplines, where each one seeks a state beyond itself, one beyond all disciplines (Iribarry 2001).

Transdisciplinarity is to join and construct knowledge through people, through teams; transversality is the way to make transdisciplinarity viable (Guattari, 2015). Transdisciplinarity and transversality are inseparable components of the processes of knowledge construction and innovation (Guattari, 2015). The literature has revealed the transdisciplinarity approach to be an important factor in the evaluation process and showed how it could positively impact the quality of research results by responding with more responsive and adaptive solutions to problems (Zscheischler, 2018).

Figure 3, below, shows a summarized spectrum of the differences between the three aspects.

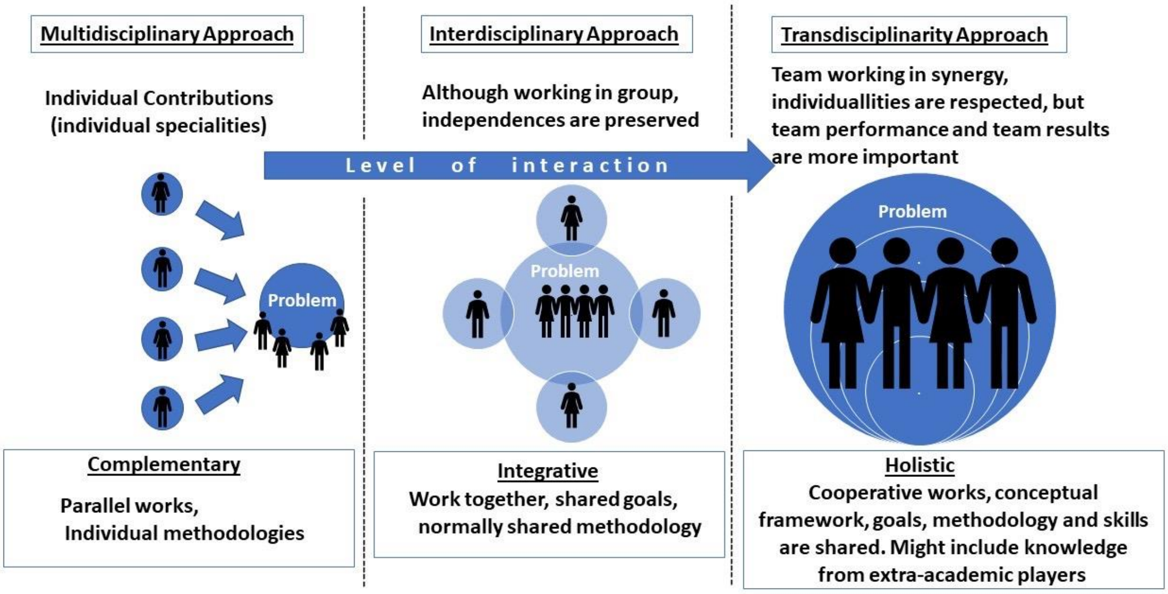


Figure 3. Basic Differences among Multi-, Inter- and Transdisciplinarity (Adapted from Oliveira et al., 2018)

By thinking of each of the three aspects (multi-, inter- and transdisciplinarity), although specific definitions exist, there is not only one formula for applying them in the evaluation process. Depending on the object of the analysis and the circumstances, each situation will demand the best available alternative for serving the evaluation's purpose (Oliveira et al., 2018). For many researchers to achieve methodological rigor, accuracy and control are only possible if they are confined to their areas of study, typically of exact or biological sciences, in contrast to human and social sciences (Mutz; Bornmann & Daniel 2015).

Constructivism

By analyzing some social and behavioral aspects in the holism and transdisciplinarity concepts related to the importance of stakeholders participation during innovation and impact assessment processes, it was observed a close relationship among them and the constructivism theoretical approach. By gathering those approaches, it is assumed that they will be structuring a solid base from the behavioral point of view to build effective innovation processes and to evaluate the impact of research with trust on data and information along the process given the stakeholders involved and their degrees of participation, mobilization, engagement and commitment.

Piaget (1967) says that constructivism is an epistemological thesis that defends the active role of the subject in the creation and modification of his representations of the object of knowledge. This means the social construction of learning by the greater community influences the individual and collective process of learning (Vygotsky, 1978). "Constructivism is not a theory about teaching…it is a theory about knowledge and learning… the theory defines knowledge as temporary, developmental, socially and culturally mediated, and thus, nonobjective" (Brooks & Brooks, 1993). “Learning involves an active process in which learners construct meaning by linking new ideas with their existing knowledge." (Naylor & Keogh, 1999, p.93).

The theoretical analysis of constructivism addressed by the various authors cited and others, leads us to understand that the process of knowledge generation and innovation will have greater or lesser positive impacts, proportionally to the greater or lesser degree of participation and engagement of the actors, directly and indirectly, related to the impacts of that innovation. If the research organization builds the culture of constructivism in the innovation process, it will create a solid foundation for a culture of impact assessment among the actors (Cirad, 2015).

The Management Approach: a base for effective leadership, engagement and conflict management

To develop teams and maintain their members engaged and focused on set goals it is necessary the leaders consider problems faced when they manage people and activities. For decades, various studies, theories and papers have been produced on leadership styles. “These theories all have in common a focus on certain behavior patterns and the implications of these patterns for leader performance” (Mumford et al., 2000). On the other hand, leadership cannot be restricted to specific behaviors, but towards the “capabilities, knowledge and skills that make effective leadership possible” (Mumford et al., 2000). Many managers and scholars scape for facing the challenge of leadership by hiding in the tasks, shift the problems, conflicts, and challenges of leading people and focus exclusively on processes and activities (Mumford, T. et al., 2007).

The process of leadership permeates an entire organization, requiring in some way, knowledge and leadership skills for managers and technicians, according to the level in which they are and the challenges they are called upon to face (Mumford, T. et al., 2007; Carmeli et al., 2006). When talking about leadership, one naturally has to approach the process of governance and management of an organization, because it is up to the leader to govern an institution, and it is also up to the leader in managing an organization or parts of it, as an organizational unit or a team.

"Conflict is a prevalent phenomenon of our lives" (Thomas & Schmidt, 1976). Conflict is a confrontation between at least two parties who are identifying incompatibility of goals, a dispute over resources or power space among others (Wilmot & Hocker, 2001). It may happen in the workplace, in the community or at home. Whether conflicts are managed poorly (competitively), outcomes will be negatives; whether managed constructively (cooperatively) outcomes will be positives (Oetzel and Ting-Tommey, 2006). Conflicts are inherent in human existence. An organization with low internal conflicts can generate stagnation, on the other hand, the existence of conflicts, up to certain limits and if managed constructively, can bring benefits to the organization (Rahim, 2017).

To create an environment of inclusivity and collaboration that can adapt to changing consumer and society needs, "leaders need to create an agile vision for the future in which employees feel they have a part to play." At a time when startups are breaking down many traditional companies, generating many disruptive innovation solutions, the incentive to continuous innovation becomes the norm. In this way, management based on conventional chains of command is no longer the best option to keep up with the current world speed. Inclusive and Collaborative Leadership is a new way for CEO, managers, supervisors and organizational leaders (Chahal, 2016).

A new approach to leadership is on Agile Leadership while basic for an organization that intends to be agile and smart, adaptable and innovative according to the world's speed. Agile Leadership considers three great key-points: Communication, Commitment and Collaboration (CLW, 2017).

4.3. An Integrative View of Impact Assessment

By adopting a systemic view, this thesis starts with a broad approach to contextualize the most specific points and shows their interactions with macro points. Thus, after making a theoretical exposition, with citation of several authors in books and articles, which will give a conceptual basis, in this stage we are converging the approach of this item to some concrete experiences in the theme of impact evaluation. However, primarily we will dissect on impact assessment.

According to Bantilan et al. (2014) assessment implies in the quantitative and qualitative analysis, making estimates or valuation and can be focused on four objectives:

- Assessment of the processes (intermediate innovation's steps while allowing to appraise the efficiency level of the organization or its quality on used resources);
- Assessment of generated products/services (outputs under the internal optic of the organization - comparative innovation's evaluation on aims planned versus reached goals while allowing to appraisal efficacy of organization);
- Assessment of generated outcomes (immediate innovation's results to direct clients, as made sales or solution delivered or technology transferred or accomplished service, and consequent evaluation under the optic of the accounting balance sheet of the company, including profit or injury statement to furnish to auditing services, stakeholders, shareholders or auditing courts whether governmental organizations);
- Assessment of generated innovation's impacts (to the environment, economic, and society - farmers, industries, services - supply-chain, local, regional and national governments, stakeholders, shareholders, and consumers).

Impacts have three dimensions to be considered (Bantilan et al., 2014):

- the space scale (local, intra-regional, national and international);
- the time scale (short, mid and long-term of effect, as well as, passing time or continuous effect), and
- the grade of impact or the intensity scale (low, mid or high intensity).

The impact is defined as the positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended. These effects can be economical, socio-cultural, institutional, environmental, technological or of other types. To construct an organizational culture of impact evaluation is always a challenge, but essential if the institution wants to reach quality and sustainability in its policies, programs, projects, processes and activities. (Bantilan et al., 2014).

To develop the impact culture means to create fertile terrain in the minds and hearts of personnel and teams involved in the impact assessment system. As a consequence of that, it is awaited that the organization will be capable of using all the results of impact studies to deliver accountability to stakeholders, internal and external auditing, supreme auditing institution, offering strategic and important information to organizational decision-makers aiming to get better prioritizing researches and increase returns on research investments (Bantilan et al., 2014). The participatory process during evaluation operation simultaneously actors' training is an essential stage for creating impact culture among the internal team and all stakeholders (Cirad, 2015; Joly, P. et al., 2016).

It is important to highlight some points related to the impact assessment: the **outputs** are the products, services or facilities that result from planned and accomplished solutions; **outcomes** are changes, learning, absorption of outputs; accordingly, outcomes' **effects are impacts**. Assessment means the use of the monitoring process and other data collected to make judgments on planned or accomplished solutions. Assessment can be focused on the *ex-ante* impacts simulated solutions to be engendered (planning stage) or the *ex-post* for already produced outcomes (accomplished stage). Thus, **final impacts** come after outcome step and can provoke direct and immediate impacts, or broad and **longer-term effects** with **indirect impacts**; but it is possible to verify **intermediate impacts** during innovation process or after outputs stage, and right away after outcomes - also called **short-time with direct impacts** (NCVO, 2017).

Products, services and facilities are examples of solutions, but for reaching them, a set of organizational processes or instruments as policies, strategies, programs, projects and activities will be necessary. Before making product and service impacts appraisal (*ex-post*), it is essential to assess those processes before implementation (*ex-ante*) as a preventive measure and a way to orientate the management innovation process to reach the success in *ex-post* impacts. This is necessary because, after they have been generated, products and services will affect the environment and people who are direct or indirect users of those solutions, and their effects will reflect on stakeholders and may also affect government policies, all of which can generate reflexes for the short-term or even for many years (NCVO, 2017).

Many articles on impact assessment methodologies have been produced, although there have been visible gaps between these and practical reality (Ruegg & Feller 2003). By viewing the dimension time, it is important to regard temporal gap between researches and impacts while meaning that there are several levels of impact, to short-term and even can reach to 30 years (Alston, 2010). Research Impact Assessment – RIA, experienced especially by agricultural sector research organizations, which search to evaluate the impact of research on the economy and society, from an *ex-post* analysis. It is a type of organizational appraisal restricted to the final activity of the research and its external impact (Joly, P. et al., 2016).

Known as 'science of science', RIA has been interesting for organizations that work on science and innovation, research ecosystems and about studies for management effective of research funding, and it is especially an approach adopted by public organizations specialized to measure economic and social impacts of its research, as also a form of accountability for governments, partners and society (ISRIA, 2017). Created in 2015, with the aim of studying and evaluating policies generated by the European Union, the Impact Assessment Institute says that: 'impact assessment' must cover all processes of a policy; from the conception stage, passing by legislation phase, to its implementation stage and consequent impacts, until the construction of a new policy, requiring monitoring and respectively *ex-ante* and *ex-post* appraisal (IAI, 2017).

5. The Key Ideas Part I

By making a synthesis of the covered concepts on Literature Review, we list some key points considered in Part I:

- **Several types of organizations have been investing time and resources to build impact assessment systems for their policies, projects, and activities.**
- **Research organizations need to show to their public or private funders the advantage of investing in research: what impacts on the economy, society and the environment are? The supreme auditing institutions require transparency of public institutions on the correct application of public resources and the impacts of their activities. The solutions' users want positive impacts from the research & innovation, they expect more productivity, fewer costs of production and**

greater profitability, for instance. The consumer wants good nutrition and health resulting from increasingly sustainable production systems that use sustainable technological solutions. To evaluate the impact, it is necessary to monitor and verify its effects in various dimensions and spatial scales, also, to measure them over time, whether they are direct or indirect.

- **For research to produce sustainable solutions it needs to incorporate the concepts of sustainability throughout the entire innovation process, from the identification and characterization stage of the demands to the technology transfer phase and the post-transfer phase, that is, during the follow-up after technology transferred, absorbed and adopted by the customers or users.**
- **The Structural Context and Behavioral Context represent two approaches to divide the various evaluation types (structural aspects) and some important theories to ensure effectiveness of the innovation and assessment processes (behavioral aspects).**

Part II – Methodological Approach

To identify, analyze and evaluate the innovation impacts, it becomes essential to deepen the science of innovation systems, as well as to identify metrics, and several aspects related to behavioral, economic, social and environmental impact's contexts. Literature review on these issues and evaluation of concrete experiences are basic (Jonkers et al, 2018).

This thesis adopts a general methodological strategy called "method of development strategy" (Contandriopoulos et al., 1994, p.41), which aims to improve some specific technology, in this thesis case, a model of innovation impact assessment.

The modeling process started with the development of a proto-model based on literature review, my assumptions, theoretical choices committed to sustainability principles and the achievement of an integrated view.

This methodological strategy is presented as a research strategy that aims to systematically use existing knowledge, to elaborate a new intervention or to considerably improve an existing intervention, or to elaborate or improve an instrument, a device or a method of measurement, including within a qualitative perspective. It means that this proto-model is a pre-conceived framework to support and guide the analysis of the experiences, and helps select what should be inspected in each case-study institution during the next steps (Contandriopoulos et al., 1994, p.41).

Then, this thesis is based on a literature review, in case study of four research organizations experiences related to innovation's impact assessment systems (especially focused on agricultural sector), a benchmarking process (capturing what was found as positive among these experiences) to finally, come up with the final conceptual model of innovation impact assessment system, as following:

- **Literature Review** – it is the essential theoretical base as input for enriching knowledge on the recent discussions (from books and papers) towards new information and concepts on impact assessment and associated knowledge, allowing a wider and deeper discussion on the theme. Therefore, a literature review was carried out on impact assessment (economic, social, political and environmental), processes of innovation, sustainability, as well as behavioral aspects indispensable for the success of innovation processes and impact assessment, including questions on management and leadership;

- **The Proto-Model** - Based on the literature review, the proto-model will serve as a reference for the analysis of the four research organizations experiences to perform the benchmarking and finally to elaborate the new conceptual model of innovation impact assessment system;
- **The Case Studies** – Studying the real experience of research impact assessment systems is essential for understanding how the theories impact the organizations' reality. Then, innovation impact assessment systems of four agricultural research organizations were studied by consulting their guidelines, handbooks, policies and all types of strategic and important organizational documents related to the innovation process and research impact assessment which were an essential input for understanding each research organization methodological experience.

The following research organizations were selected: Inra, Cirad, Embrapa and CSIRO, two from France, one from Brazil and one from Australia, as relevant actors of technologies production to the market of grains, meats, fruits and dairy, among other products, including agro-industrial products. As an unfold stage of the case studies, a field experience was carried out to test some data collection tools, where some Embrapa stakeholders were contacted to test some tools: interviews, meetings and field visits beyond the analysis of secondary data given by them and by the Embrapa;

- **Benchmarking -** a benchmarking procedure was implemented to identify and learn with successful experiences, and thus improve the proto-model. It corresponds to a necessary step to refine the proto-model. In each institution, a set of procedures to evaluate the innovation capabilities of their researches were listed. Those procedures and approaches considered the most appropriate concerning the type of work to be performed, were highlighted and carefully analyzed. It was sought to insert those that could provide greater completeness as a management system; and

- **The Final Conceptual Model of Innovation Impact Assessment Management System –** After literature review, case studies and the benchmarking process, the proto-model was reviewed and a definitive conceptual model of innovation impact assessment of researches was presented. This overall pathway of the research is presented in Figure 4 below.

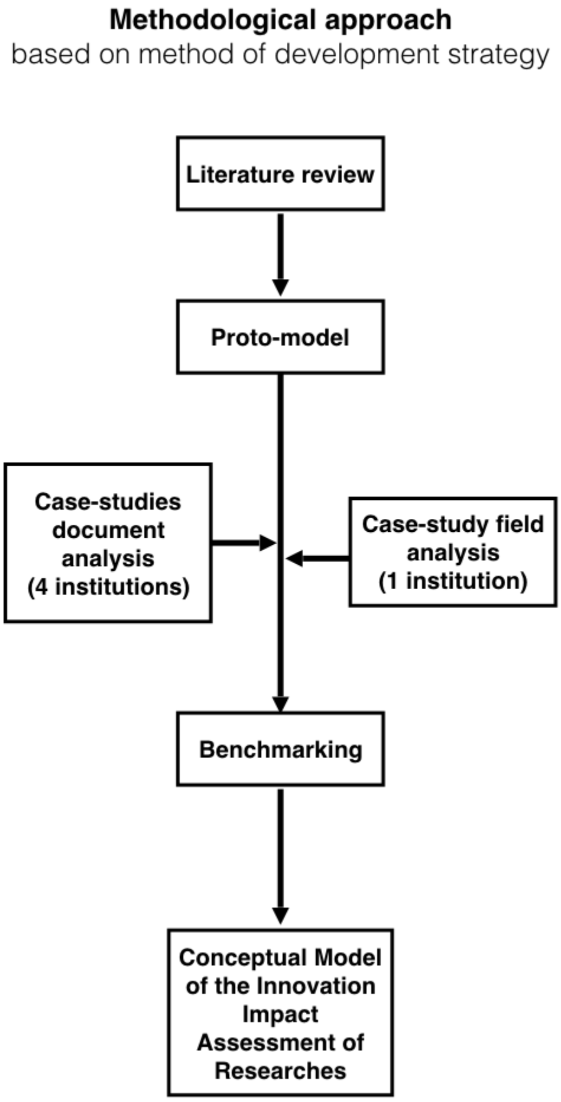


Figure 4. A general flow chart of the present research

1. The Proto-Model Development

Innovation Impact Assessment of research should be a broad, deep and optimized process.

In this sense, a large spectrum of variables and indicators, as well as new approach attempts would be necessary to demonstrate gaps or weaknesses. Qualitative and quantitative methods are imperfect means of evaluating impact assessment processes with accuracy, when performed separately. Thus, it is advisable to use both methods for impact evaluation processes (Grant et al. 2010).

This thesis uses a qualitative method for analyzing and discussing theoretical descriptions and research organization methodologies and adopts quantitative parameters and qualitative approach as a base for constructing the new model of the innovation's impact assessment management system.

Eight variables were adopted as the basis of the proto-model for Innovation Impact Assessment: Connection with Institutional Policies and Strategies; The Existence of a Framework for Impact Assessment; Connection with the Process of Innovation; Insertion of Concepts of Constructivism, Holism and Transdisciplinarity; Sustainability by a Cross-Cut Perspective, and Process Analysis, which are described below:

a) **Connection with Institutional Policies and Strategies** is important to verify whether a research organization considers impact assessment as part of its policies, as it plays an important role in its strategies and the way policies and strategies related to impact assessment are monitored and managed (IAI, 2017).

b) **A Framework for Impact Assessment** allows verification of how the institution is inserting impact evaluation into its organizational structure, whether it represents a continuous or temporary process. This reference analysis is important for verifying the relation of time versus the availability of organizational structure as a driver for impact evaluation processes. It allows identifying the presence or lack of process continuity and, similarly, verifying whether there is a whole perspective through a systemic view, without risk of interruptions, which may indicate variable institutional commitment to impact assessment (IAI, 2017; ISRIA, 2017; Barros de Mendonca & Laques; 2017).

c) **Connection with Process of Innovation** allows us to verify how an institution correlates the process of innovation with the impact evaluation, and also enables us to make correlations via systemic vision, from a preventive perspective of impact (*ex-ante* impact analysis, following the innovation pathway) to an impact after outcomes have been achieved (*ex-post* impact analysis) (Ruegg & Feller 2003; Schumpeter, 1983; Greenacre et al, 2012; Stanleigh, 2017; UN, 2017; Planing, 2017; Chesbrough et al, 2006; Cirad, 2017; Cirad, 2015; Barret et al., 2018).

d) **Concept and Practice of Constructivism** offer important bases for reinforcing the capacity building of actors for the construction of collective knowledge, the generation of co-creation and the propitiation of effectivity of participation in the evaluation process. It is essential to emphasize that understand the concept is basic, but not enough whether it has not been conducted to the practical world (Vygotsky, 1978).

e) **Concept and Practice of Holism** set conditions for integrating all stakeholders during the innovation and evaluation processes, creating client and actor commitment during all steps of innovation and impact evaluation (including non-academic participation) beyond enriched results (Freeman, 2005; Cato, 2009).

Transition Management (TM) can be considered as a way for facilitating the implementation of holism concept. TM has been a recent approach in an attempt to answer new ways for governance into complex and multiple scenarios, immersed in uninterrupted change and uncertainties demanding a sustainable society. These approaches (experienced by the Dutch government) search to adopt flexible and adaptable structures for working into an ambiance with fragmented policies that require resilient behavior, stimulating knowledge and technological changes, innovation, and incremental improvements, especially paying attention to relevant actors. TM creates adequate conditions for legal compliance and for navigating with effectiveness in this dynamic social, economic and ecological environment (Loorbach & Rotmans, 2010).

Therefore, TM is a holistic approach that operates under a cross-cut vision and asks for systemic models that can view from policy/strategy stage, passing by tactical, operational and monitoring /evaluation stages, and understand that one stage cannot be effective without another.

f) **Concept and Practice of Transdisciplinarity** represent an approach into the innovation process and impact assessment system opens opportunities for a wide spectrum of knowledge and specialty contribution aiming to solve complex problems by collective creation, to achieve societal demands and to offer a responsible answer to complex environmental demands. Transdisciplinary teams enrich the innovation process, as well as their outputs, outcomes and impacts (Guattari, 2015; Iribarry, 2001).

Transdisciplinary approaches require attention to three aspects: cognitive, structural and processual.

> "Effective cognitive leadership provides a vision that links and motivates transdisciplinary researchers to step beyond their disciplinary lens, relax old assumptions and search for creative frame-breaking solutions. Effective structural leadership adds value by creating needed bridges among unconnected parties. Effective processual leadership encourages trust and turns potentially destructive conflict into constructive interactions" (Zscheischler, 2018).

Transdisciplinarity is a wider approach, with the exercise of empathy, including social and all stakeholders' participation for policy and project construction, not restricted to scientists and policymakers. It is necessary to adopt an open-minded attitude for new learning and experiences and, thus, permit the construction of a hybrid approach, multidiverse and responsive to the height of complexity that the issue requires. We need to respect all areas of scientific knowledge, traditional knowledge and valuable knowledge tied to professional and life experiences. Transdisciplinarity demands for attitude to auscultate the others, including citizens, consumers, all kind of producers, representative members of society, that is basic to construct sustainable societies (Popa et al., 2015).

Scientists who are working with sustainability issues recognize the urgency to migrate from restrictive multidisciplinary and interdisciplinary approaches towards transdisciplinary collaborations, which implies joining scientific and extra-scientific expertise (Popa et al., 2015).

When we address the relevance of transdisciplinarity, at least we are informing that Social, Political and Environmental Impact Assessment is linked to economic assessment and that we should adopt all of them for an integrated assessment process.

g) **Sustainability by a cross-cut perspective** represents an important approach when seeking to build a system for assessing the innovation impact within current parameters and future trends. The United Nations policies have reinforced the importance of country-level initiatives focused on a cross-cutting vision of development, i.e. with the overlapping economic, social and economic dimensions and operating by an integrated and systemic approach (UN, 2015).

This position was addressed in the Cato (2009) model, when it emphasizes the need to visualize sustainability dimensions through a cross-section in which the environmental component represents the larger environment, within which society is inserted and where the economic component is respectively inserted, all acting in an interdependent way. The economic and social dimensions, largely emphasized by many research organizations, are extremely important for the sustainability of the institutions, however, they need to be closely linked to the concepts of environmental sustainability as a condition for the sustainability of the production systems, as well as for driving the planet quality of life (Greenacre et al., 2012; Planing, 2017).

h) **Process analysis** provides the ability to go beyond the planned structure of impact analysis; it means analyzing each pathway of methodology, which can clearly show if the practical world is well monitored and managed (ISRIA, 2017).

Finally, the Proto-Model starts from a macro and contextual approach to a more accurate and timely focus. Each of these references was analyzed considering the historical process of impact assessment in organizations and what is new about this issue, its nuances, its different concepts and approaches, as well as factors such as social pressures, policies, agreements and international protocols, among others.

It is a basic condition of sustainable agricultural production to verify if there are sustainable agricultural technologies, if they are available and accessible to the productive sector and to determine whether technological solutions are indeed sustainable. Thus, it is essential to evaluate their impact on the productive sector, society in general, economy and the environment. The necessity for this proto-model is because, “the mainstream scientific methodologies are often poorly equipped to deal with complex sustainability problems” (Popa et al., 2015).

2. The Benchmarking Procedure

Benchmarking can be summarily defined as the process of evaluation and applying the best experiences or practices that provide possibilities to improve the quality of other processes or organizational practices (Ahmed and Rafiq, 1998).

Benchmarking is a very usual practice lately and of great value, given its practicality, a gain of time and usually low cost, compared to the new research or search for something totally new. It is important to understand that benchmarking seeks to identify successful practices and, by bringing it to your organization, it is fundamental to analyze its suitability for its own environmental, cultural and business contingencies, and also, it is important to promote some leap or improvement over that reference originally studied. (Raymond, 2008).

Knowing the experience of four organizations in the field of research impact assessment represents an important positioning of ideas about the state of the art of this theme experienced by research institutions of renowned relevance in the world, identifying positive points and fragilities or gaps to be corrected or improved, by focusing the innovation view.

This comparative analysis made it possible to verify that positive identified aspects could integrate a new design of innovation impact assessment model, based on a cross-cut focus of sustainability and supported on benchmarking practice.

3. The Case Studies

3.1. Case Studies for Refining Proto-Model

After citations and analysis of some theoretical approaches, this thesis looks for reaching in some practical experiences of research organizations. As seen before, organizations (governmental, non-governmental or private) represent the way for implementing United Nations agreements, international policies and protocols towards sustainable development goals. In order to choose what institutions could be taken as case-studies for the benchmarking process, CGIAR database and OECD's comparative study of research organizations approaches of impact assessment were consulted (Joly et al., 2016).

CGIAR is a global research partnership for a food-secure future that congregates 15 agricultural research centers around the world (CGIAR, 2017). A large percentage of CGIAR investments are applied to issues related to natural resources research and, observing the importance of identifying the impacts of its research, created a group dedicated to the study of impact assessments with economic, social and environmental dimensions. Its Research Impact Assessment looks for evaluating *ex-post* impacts of their developed technologies when used in the field and creating links from generated data and information to support *ex-ante* assessment and guide plans, as a way to improve research management and to be transparent for their financiers (Merrey, 2015).

Despite limited parameters of aspects that were analyzed, the OECD study allowed to verify some important points of Cirad, Inra, Embrapa and CSIRO methodologies of research impact assessment (Joly, P. et al., 2016), and it was relevant as one of the criteria to select these organizations for making a comparative analysis. On this way, the OECD study has demonstrated that these institution experiences could be used as a substantial reference for the thesis objective.

By verifying the global scenario in the agricultural production and trade sector, it is possible to identify some important players in food-producing countries such as France (the sixth in the world ranking), Brazil (the third one) and Australia (the eleventh). In the European continent, France is the most important country regarding agricultural production and export, including the nation, which receives the greatest impact of the agricultural sector on the entire economy of the country. Brazil is the first in Latin America regarding production and exports in the sector. Despite being classified as the 11th in the global ranking of agricultural production and export, Australia is the first in the continent of Oceania and has been an example by the resilience view in tackling the challenges of climate and soil with highly-skilled agriculture. (FAO, 2015; Mediamax, 2016; AG, 2010).

It is inevitable to connect their high production and technological advancements in this field without adding their important agricultural research organizations. Then, to enrich this work and create a concrete base to develop this thesis, we decided to embrace case studies of four research organization of these three countries, by representing America, Europe and Oceania continents. These study cases are important by allowing a practical and deep analysis, including a confrontation between theories and the real world and, hence, engender conceptual base for constructing a new model of impact assessment system applicable to agricultural research organizations by a cross-cut perspective of sustainability.

In France, there are two important agricultural research institutions: L'Institut national de la recherche agronomique – Inra (in English, the National Institute for Agricultural Research), and Centre de coopération internationale en recherche agronomique pour le développement – Cirad (in English, Center for International Cooperation of Agronomic Research for Development).

For some years, both institutions have been developing systems for evaluating impacts of their agricultural research, primarily focused on the socio-economic impacts and more recently they have included the environmental dimension. Inra asserts that research contributes not only to generate scientific knowledge, but they also have to be aimed towards agriculture, supply chain, food and the environment using innovating in production. Based on the Research Impact Assessment – RIA - approach, this institution implemented a document called ASIRPA (Inra, 2016), which represented in a methodology for analyzing effects from their research, with a strong emphasis to agronomic and socio-economic impact to producers and supply chain (Colinet et al., 2014).

Called Impress (IMPact of RESearch in the South), Cirad has developed a system for evaluating impacts of its technologies adopted by producers. This organization understands that in order to assess the impact, it is necessary to grasp the recent innovation concept and how the innovation process demands a collective complex interaction among actors. The main role of a research institution is to develop research, but when it comes down to the facts, sometimes the cause of impact results from different activities that are not necessarily the research, considering the current speed of information, the dynamism of creativity's process and the innovation. Interaction among actors generates complex combinations, technologies and respective impacts. (Barret et al., 2015).

Therefore, to analyze impacts, by Cirad's view, it is fundamental to connect policies, strategic plans, programs, projects and activities, and its outputs, i.e. products/services, and to understand that to build all this process demands an open innovation perspective (technological innovation and management innovation) and active inter-relationship with co-creation assembling actors along the whole process. While research contributes, sometimes strongly, to impact, it does not mean that some impacts can result from a lack of interaction with research (Barret et al., 2015).

In order to analyze impacts the organization may use two pathways: *ex-ante* (it will analyze the relation among programs, projects, output/outcome supported by a hypothetic path and projecting expected results and impacts) and *ex-post* (comparatively analyzing what was planned and what was reached regarding the outcome and its consequences in the development) (Barret et al., 2015).

Since the 1970s, Brazilian Agricultural Research Corporation – Embrapa has been developing impact assessment systems. In the beginning, it focused on economic impact analysis, especially due to the financial restriction for the public sector, by considering that governmental resources essentially support this organization and impact analysis would be a way to demonstrate to the federal government its institutional and economic effectiveness. After the 2000s impact analysis became multidimensional by including social and environmental dimensions as part of this process, generating a Social Balance, based on integrated impact assessment and mainly supported by a methodology called Ambitec-Agro (Rodrigues et al., 2010).

Recently, as a result from a request of the Brazilian Supreme Audit Institution, Embrapa has inserted Social Balance as part of its financial and accountability report, generating an integrated report that reflects the social, environmental and economic impacts. It results from its technologies and services produced, as well as demonstrating its transparency in relation to the government's and society's expectations on the application of its resources. Recently, some points related to public policy impact have been considered in the Social Balance Report (Embrapa, 2017).

The Commonwealth Scientific and Industrial Research Organisation - CSIRO is an Australian governmental research organization that operates for several productive sectors such as Agriculture, Health and Biosecurity, Information and Communications Technologies, Energy, Food and Nutrition, Land and Water, Manufacturing, Mineral Resources, and Oceans and Atmosphere (CSIRO, 2015; CSIRO, 2017).

In CSIRO's opinion, producing a positive impact from its research is not enough. In order to fulfill its mission, it elaborates an annual report on its research impact as well as a CSIRO Annual Report about its operational and scientific performance.

> "It must provide its stakeholders (and itself) with robust evidence that this goal is being accomplished. To answer with concrete facts for stakeholders is the purpose of CSIRO's impact evaluation activities: to provide firm evidence (rather than assumptions or hearsay) of the effects of CSIRO's research and innovation activities on the economy, environment, and society" (CSIRO, 2015).

3.2. Characters of Chosen Institutions

INRA

Inra is the French National Institute for Agricultural Research. It is a French public research institution that focuses on issues related to agriculture, food and environment, with a particular emphasis on sustainable development and agroecology. All supported by governmental funds, this institution adopts, as its impact assessment system, the Impact Analysis of the Public Agronomic Research – ASIRPA, which is highly based on RIA (Inra, 2016). It has a strong evaluation of agronomical and economic impacts. It has been important to demonstrate efficacy and effects to producers, supply chain, and Gross Domestic Product - GDP aiming economic sustainability as the base for institutional sustainability (Inra, 2016).

It represents important feedback for policies and strategies adjustments and to renew research priorities, but it would be interesting to set a clear pathway to reach efficacy on this feedback mechanism. INRA does not have a permanent or fixed organizational unit to manage the research impact assessment process, and its structure works temporarily, per impact evaluation project. Despite that, there is an organizational unit in Inra; it is the Ethical Advisory Committee for Agronomique Research. This Committee analyzes public agronomic research impact and provides information to the ASIRPA system, as well as, feeds the upper management about the research of internal profitability (Inra, 2016; Inra, 2015).

CIRAD

Cirad is the French organization for agronomic research and international cooperation for the sustainable development of the tropical and Mediterranean regions. This research organization adopts a system called IMPact of RESearch in the South - IMPRESS (Cirad, 2015), which is based on the Research Impact Assessment – RIA approach, but with visible advances in incorporating social and environmental dimensions and also by hearing stakeholders. The conceptual approach creates an expectation to link strategic and operational levels but, after case studies, results seem to reduce reflexes or feedbacks only to the operational level, and it is not clear how it will connect results to the strategic level with effective impact to research priorities by using feedback mechanisms (Cirad, 2016).

The impact pathways are one aspect emphasized by this approach because it allows identifying barriers and positive points with more facilities along the impact route, through its short, medium or long-term, as well as, with direct or indirect effects.

EMBRAPA

Brazilian Agricultural Research Corporation – EMBRAPA, is the system-core of the Brazilian National System of Agricultural Research – SNPA. This institution is more than 95% of its budget supported by governmental funds (Embrapa, 2018). Embrapa has a system of research impact assessment composed of two linked methodologies: Social Balance Report and Ambitec-Agro (Junior et al, 2014).

Annually Embrapa produces its Social Balance Report that is a strategic report directed for stakeholders, federal government court of accounts and society in general. This report adopts a method to compact and synthesize information composing an institutional document by a sampling of the three most important technological solutions generated by each one of its 41 research centers. The document searches to demonstrate the effects of their technologies to supply chain, farmers, local and national population directly or indirectly affected by adopted technologies, and also, economic surplus and internal rating of return estimation (Junior et al., 2014). The Ambitec-Agro (Integrated Impact Assessment) is an operational methodology that feeds of data and information the Social Report elaboration by an aggregation process of information, aiming to generate a strategic profile document (Rodrigues et al., 2003; Rodrigues et al, 2010).

CSIRO

CSIRO is the Commonwealth Scientific and Industrial Research Organisation, the national organization responsible for scientific research in Australia. About its budget, this organization is supported by 60% percent by governmental funds, and the difference, by private, non-governmental and other financers. CSIRO supports its impact assessment process on the value that the organization can transfer to its customers, users and all its stakeholders. It considers that transferring value to stakeholders means ensuring confidence in their organizational capacity to generate solutions and innovations with a high degree of positive impacts and thus guarantee their institutional sustainability (CSIRO, 2017).

“CSIRO to be Australia’s Innovation Catalyst: not only assisting its customers within industry and government to innovate, but increasingly, to support and improve the functioning of Australia’s entire innovation system” (CSIRO, 2015).

Annually, CSIRO conducts its research impact assessment process by an external and independent organization and publishes its innovation impact report, with a broadly participatory and consultative process by the stakeholders, which are classified according to the degree of influence and importance throughout the innovation process, as well as their influence on impacts on customers and users (CSIRO, 2017; CSIRO, 2015).

3.3. The Learning Process from Each Institution (planning what to see, how to see)

Data and information on the four research organizations will be collected through institutional documents such as strategic plans, documents containing the description of their research impact assessment systems, including operational handbook (guidelines) for those systems.

Other data were captured from participation in technical meetings (Embrapa, in August 2017, and Cirad, in November 2017) and a workshop when I had a meeting with a senior CSIRO official (during training in Research Impact Assessment, in October 2017), when discussions were held on the respective research impact assessment systems. There were also captured information from the technical report on comparative analysis of impact assessment systems of these three research organizations, plus the Inra system (Joly et al., 2016).

As showed before, based on literature review important aspects are recommended to be considered in impact assessment systems. In this way, comparative analysis of four organizations adopts:

- Connection with institutional policies and strategies;
- Framework for impact assessment;
- Connection with innovation process;
- The process of innovation and the impact assessment process under the constructivism, holism and transdisciplinarity concepts;
- Under impact analysis from an environmental, social, economic and political view, focusing through a cross-cut perspective of sustainability; and
- Process analysis, by viewing the impact path perspective, including *ex-ante* and *ex-post* assessment process.

The comparative analysis based on these variables will allow us to generate important conclusions about how these four organizations achieve their results in assessing the impact of the research and at the same time, it will serve as input to guide the future model of innovation's impact assessment management system.

It is important to emphasize that the issue of governance and management represents a cross-cutting on all of these variables, with particular attention to behavioral themes, as crucial to success in achieving planned innovation goals and their respective positive impacts.

By analyzing impact assessment concepts and experiences, and confronting them to a cross-cut of sustainability, holistic, constructivist and transdisciplinary perspective, it is inevitable to understand that it would be necessary governance and managerial system see a complete process that begins at the policy and planning stage, go through the tactical level and reach the operational level.

The operational level will generate products and services to be delivered to supply chain and consumers, affecting microeconomic environments, with greater or lesser effects to macroeconomic, and impacting the ecological environment at more or less different scales. In order to meet positive expectations and impacts, the Transition Management (Loorbach & Rotmans, 2010) and Sustainability Transition (Markard et al., 2012) approaches would express important contributions to be recovered for a more complete and integrated approach of sustainability impact assessment applicable for agricultural research institutions or any organization.

New practices often require new paradigms and desertion of ongoing practices that will occur when decision-makers recognize a simple truth: “Sustainability = Innovation” (Nidumolu et al., 2009). “A major target of the SDG agenda is the eradication of hunger” (FAO, IFAD and WFP, 2015), the world increasingly demands food production, and well-nourished people, now and to the future, requiring agricultural productivity by using sustainable solutions (FAO, IFAD and WFP, 2015).

4. The Field Experience

The purpose of the field experience is to test some data and information collection tools. This activity is not intended to be a field survey with a lot of quantitative sampling, but a way for testing some survey tools, by a qualitative and perceptive work of the local reality, with a much-focused sample in a detailed survey of the opinion of some stakeholders. It consults representative leaders of the agricultural sector, who are managers of associations that represent thousands of producers. Information gathering will also include other stakeholders of the agricultural research and innovation, such as members of rural technical assistance, researchers and representatives of the Ministry of Agriculture (where public policies are elaborated for the agricultural sector, with strong impacts on research).

This stage was important to feed with field data and information the new model of impact evaluation designed in this thesis. Thus, this activity was important as a mechanism to assist in the choice of the most appropriate survey tools for insertion in the new model to be designed. This field experience would also be an opportunity to collect other perceptions and information related to positive points and weaknesses that connect the links of the value chain, where occurs the connections between research & innovation - technical assistance - producer-consumer - society in general and environment. These can be considered as supplementary information, with important subsidies for future research work

4.1. Field Experience Methodological Approach

Discussions and controversies about qualitative versus quantitative methodological approaches were particularly prominent in the 1960s, especially due to Kuhn's (2012) thought. He emphatically contested the quantitative approach by demonstrating the risks of pursuing data and information only as a "mathematical" goal. This way would lead to the capture of data and information too biased when the research was social, or that took into account groups of people with their cultural nuances, behavioral, fears, psychological pressures and the play of interests among other factors.

The point of view of the qualitative approach, however, is that the scientific models of the natural and social sciences are differentiated, given the distinct nature of their objects. The human action is intentional and reflexive, whose meaning is apprehended from the reasons and motives of the social actors inserted in the context of the occurrence of the phenomenon, which does not happen with the physical objects, the focus of analysis of the natural sciences (Kemmis & Mctaggart, 2000).

Every research technique has a range of action, containing their limits and fragilities. It means that there is no perfect methodological way, however, so that the results of the research come to reflect the reality of the context or universe searched. The research will require consistency in the chosen methodologies conceptual models, given the object and social group to be studied, and also, knowledge and mastery of the technique by the researcher. This approach applies to the case of research instruments, as is the case with interviews. Both methodological approaches, quantitative and qualitative, are important and should be adopted in an integrated way as far as possible and appropriate to each situation, group and context to be researched. (Kemmis & Mctaggart, 2000).

The qualitative approach understands that human action always has a subjective meaning that cannot be captured only from a quantitative and objective approach. The meaning subjective refers to the content in the conscious or unconscious mind of the person and even as to the intersubjective meaning refers to the set of rules and culture that favor the sharing of beliefs by groups of people inserted in a particular socio-cultural context (Minayo et al., 2000).

Usually, in qualitative research, semi-structured and unstructured interviews are chosen. The choice of one or another instrument depends on the level of directivity that the researcher intends to adopt. It can vary from the interview, in which the interviewer introduces the research topic and leaves the interviewee free to discuss it, making only occasional interferences, until the somewhat more structured interview, which follows a script of topics or general questions, or even a mix between the two paths (Bartholomew et al., 2000).

There is an awareness that the number of producers interviewed is low to consider a representative sample within the universe of Brazilian rural producers and even within the state of Mato Grosso, although it is restricted to the group of large producers or business producers. However, it is worth noting that representative leaders of the productive sector were interviewed (the National Confederation of Agriculture and Livestock and the Federation of Agriculture of the State of Mato Grosso), which in a way mirrors the sector's opinion, despite some biases, which is inevitable in any research process.

It was adopted the option of using semi-structured interviews, including closed and open questions, with flexibility so that the interviewee could freely express their opinions on the topics considered there.

However, during the lunchtime and along the farm visits were observed great opportunity for continuing the conversation, by adopting unstructured interviews, without formality and psychological pressure, in which they could progress freely in some issues. This situation also created moments without self-checks or superego pressures, by adopting the language and concepts of Analytical Psychology. There was an expectation that these instants could offer information with the possibility of greater expression of the truth. Excessive formalities often create blocks for the expression of truths, especially when certain information may hurt the image or interests of individuals or institutions. And this can be visible in the evaluation processes (Todorov, 2004).

4.2. The Choice of the Institution for Field Experience

The research tools could be tested in any of the four institutions studied, but it was tested by Embrapa's performance because of the following criteria:

a) availability of Embrapa researchers to support fieldwork;

b) access facilities for Embrapa's stakeholders, especially rural producers working on field projects with Embrapa, as well as representatives of organizations in the sector, as well as access to rural technical assistance workers.

4.3. The Learning Process from the Field Experience

Based on the above contextualization, the aim of field experience was:

- To obtain data, information and methodological experiences to feed the construction of an improved innovation impact assessment model;
- To analyze the best options in terms of tools for collecting data and information by observing local reality and dialoguing with the users of a sample of Embrapa's technologies;
- To identify positive points, gaps and barriers throughout the steps of the process from policy formulation, research, technology transfer, technical assistance, and practical actions of farmers and its reflexes related to the use of survey tools.

5. The Final Conceptual Model of Innovation Impact Assessment

The final conceptual model of the innovation impact assessment management system will be the result of all previous parts, it will be the end product of this thesis and will be detailed in Part III. Thus, this model will be resulted from the literature review and benchmarking practice especially product of capture of positive aspects detected from the comparative analysis of four research organizations, as well as from specific analysis of one selected research organization (Embrapa, in this case), and hence positive methodological information as well as tools captured and tested from the field experience.

Part III - The Proto-Model; Case Study of Four Research Organizations: observations and conclusion; Benchmarking; The Final Conceptual Model

The Part III represents the final part of this thesis, which is composed of four items: The Proto-Model; Case Study of Four Research Organizations: Observations and Conclusion; Benchmarking; The Final Conceptual Model.

This part seeks to converge the conceptual basis, synthesized in a proto-model, and then to enter into the analysis of four practical experiences on impact assessment of innovation, proceed to capture the positive points found in these experiences until finally arriving at the model of an improved impact assessment system. See the description of each item, below.

1. Here the proto-model description is verified, based on the literature review, which will serve as the reference for the analysis of the four research organizations studied.

2. It shows what was observed and concluded in the analysis of the four research organizations studied.

3. It displays the positive and useful aspects for this research and consequent conceptual model construction, observed in the experiences of the four studied organizations.

4. It describes the final conceptual model, its characteristics, evaluation elements to be applied and other operational aspects, based on benchmarking, complementing and refining the proto-model.

1. The Proto-Model: a conceptual base for an innovation impact assessment system

The proto-model was developed based on the literature review and from now on aims to serve as a parameter for the innovation impact assessment model to be constructed. After analyzing the innovation impact assessment experiences of four research organizations the next step is to improve the proto-model, passing by the benchmarking approach and to arrive at a model as ideal as possible to be applied by research institutions. The following citations summarize the major structural aspects for fitting the proto-model framework.

The gateway to this thesis is the United Nations sustainable development goals. It operates as a driving force for the development of the innovation impact assessment management system and its targets as well as an important beacon to a consistent innovation process.

The United Nations Sustainable Development Goals (SDG) show that from the 17 Goals, 7 has a direct or indirect relationship with the agricultural activity, particularly, research and innovation organizations have a key role for reaching the SDG 2 and 12, while food production must be increased by a sustainable way of production (UN, 2015). After mandatory decisions of the International Organisation of Supreme Audit Institutions (INTOSAI, an organism of the UN) referred to needs for public organizations to contribute to good governance and to promote sustainable development through citizen mobilization and participation in public auditing processes. It is important to remember that most of the agricultural research organizations are public institutions (UN, 2015).

As part of the social and economic context, the agricultural sector requires to rethink towards new jumps of understanding and sustainable solutions to the field and supply chain. The traditional economic thinking is still linked to the old understanding, while environmental impacts are externalities. Environmental impacts must be considered as internalities of social and economic dimensions (Cato, 2009).

It means that to an innovative, realistic and sustainable view, a reference's model of impact assessment system has to be based on a cross-cut view, by prioritizing environmental dimension over the social and this one over the economic, by understanding that there is a logical overlay majoring one over the other (Cato, 2009). If we deteriorate the environment and its resources, we deteriorate the primary basis of the economy and its reflexes on society will be inevitable, in addition to the strong and systemic interrelationship among them and although we have seen, throughout history, that technological advances can reduce the negative impacts of the economy on the environment (Cato, 2009).

The agricultural activity interface with the natural resources, social and economic dimensions, thus, to meet the UN sustainable development goals, the agriculture must be sustainable. In order to reach that, agricultural research organizations have to generate sustainable technological solutions to agriculture. To achieve these goals, it is basic that the innovation process considers a cross-cut perspective by a sustainability dimension.

When evaluating research related to production, it is not enough to assess production processes and outputs; instead, impact appraisal is the key point for identifying farmers, industries, services and consumers satisfaction, and improving producer's quality of life, their profitability and the effects on the environment. Many research organizations have found a way of demonstrating to the government and society the economic returns from governmental research investments by developing impact evaluation systems (Alston, Norton and Pardy, 1995). But it is necessary to go beyond the assessment of social and economic impacts; it is important and necessary to evaluate environmental impacts.

According to literature review it is important to develop a model grounded on a focus of sustainability seen by transversality of its various components, from the environmental, to social and to economic, respectively (and it is also advisable to insert the political and policy dimensions). It is basic on the sustainable development concept that there is an interdependence between them, but at the same time, it needs to consider a scale of value among them (Cato, 2009).

By avoiding bias of research teams, the impact assessment system must be impartial, driven by independent and external teams and focusing on the impacts pathway, following step-by-step of supply chain, including a unique managerial system of *ex-ante* and *ex-post* evaluation timing, generating recommendations of stakeholders, and input for organizational decision-making processes (UNDG, 2011; Mergaert and Minto, 2015). It means that the last expected impacts on the environment, society (included politics) and economy must be the unremitting reference (the reminder posted on the wall) which should be sought as final goals. An impact evaluation system also has to insert the understanding that there are several impact scales: space scale; timescale, and the grade of impact or the intensity scale (Batilan et al., 2014).

When referring to space scale, and adopting an example for the context of an agricultural research organization, it can understand that the environmental, social and economic impact generated by a technological innovation can reach: the place where technology was tested and in the farms where they were adopted. Then, this technology adoption may impact the biodiversity, soil, water system, air, by the emission of carbon among other effects, generating or withdrawing employment and income, improving or worsening the profitability of the producer, among other effects. These impacts can affect the aggregated spaces in the supply chain where the product generated by that technology moves (Batilan et al., 2014).

When talking about time scale, and use the same organizational context, it refers to the maturation time of one or more impacts, which may be immediate, or may take months, years or decades to positively or negatively affect the environment, society or economy. The degree of impact or intensity scale refers to the level of intensity that one or more impacts can generate. The impact can be mild, medium or high intensity (causing little or big damage or low, medium or high reflexes, and it may be positive or negative) (Batilan et al., 2014).

The Proto-Model, as shown in Figure 5 below, was developed from the literature review and it represents the conceptual framework on which the model of innovation impact assessment management system is supported. The Proto-Model demonstrates that the impact assessment system is an open system, with a high degree of interaction between the internal organizational environment (of the research institution) and the environment, social, political and economic dimensions, including stakeholders, clients and users of innovation's solutions as well as the external environment (ambiance).

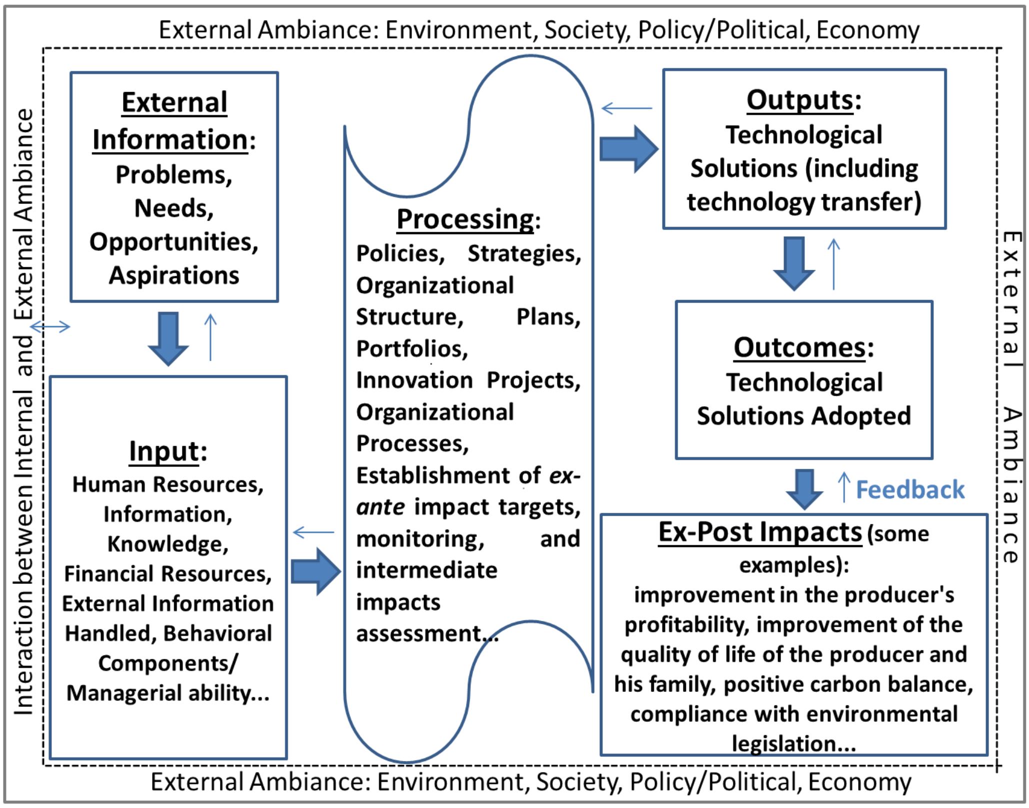


Figure 5. Proto-Model of Innovation's Impact Assessment Management System (Adapted from Jonkers et al., 2018 and Goldstein & Renault, 2004)

According to Figure 5 above, the proto-model adopts eight variables as a structural base which will permeate all stages of the above system (Jonkers et al., 2018; Goldstein & Renault, 2004; Kuby, 1999; Cato, 2009; Metherbe, 1986; Law and Kelton, 1991; Buckley, 1976; Markus et al., 2002; Rodrigues et al., 2010; Avila, Rodrigues and Vedovoto, 2008; Douthwaite, 2003; Joly, P. et al., 2016):

- **Connection with institutional policies and strategies** - the information and signals coming from the external environment should guide the construction of policies and institutional strategies and in the scope of these must be included the system of impact assessment as an institutional priority. And also, there should be a systematic connection between the demands and needs of the external environment, with the innovation process and both, in turn, integration with the evaluation system of the innovation's impact;

- **The existence of a framework to evaluate the innovation's impact** - It is essential for the research organization to have a structure to manage the innovation impact assessment process, preferably driven by a permanent structure. A stable or permanent structure is a way to avoid discontinuities in actions, as well as to allow continuous monitoring of the impacts generated by the organization, facilitating the review of research policies, strategies and priorities;

- **Connection with the innovation process of the organization** – by aiming to monitor the innovation process, step-by-step, the impact assessment system must be coupled with the innovation system, which will allow course adjustments throughout the innovation process, through *ex-ante* impact analysis and later to promote adjustments of innovation policies, strategies and priorities after *ex-post* impact assessments;
- **Concept and practice of constructivism** - the insertion of constructivist approach must be coupled with the institutional policy of innovation, as a way to guarantee harmony among the stakeholders' demands, policies, priorities, the process of innovation generation, and the innovations' impacts stages. These concepts must permeate the impact assessment process of innovations as a way of giving reliability of data and information collected from external and internal actors. In order to conduct a constructivist process, it is essential to adopt effective managerial practices, so that there are effective participation and synergy of the actors;
- **Concept and practices of holism** - The insertion of holism concept is essential in the process of generating innovation's solutions, as well as in the assessment of their impacts. To understand that all the parts that integrate the universe of external and internal actors of the organization must participate in the evaluation of the impact of these innovations, since they are indissociable parts, whether they have a direct or indirect influence on the research organization and on what it produces for the society. It is important in this context to classify the degree of importance and influence of each stakeholder, that is, how directly or indirectly it can influence the innovations' generation and their resulting impacts; also, what impacts (including the degree of intensity and effects over time) can affect each of the stakeholders;

- **Concept and practice of transdisciplinarity** - This concept denotes action's forms that integrate people from different areas of knowledge and institutions representing the external and internal environment during each step of the innovation construction and process of impact evaluation, propitiating synergy and generation of results favorable to reach impacts in tune with stakeholders' needs and desires;
- **Adoption of the concepts of sustainability by a cross-cut view**- It is necessary not only to integrate the economic, social, political and environmental dimensions, but to visualize them transversely, interactively and in a holistic, constructivist and transdisciplinary perspective. It important to make integrative analysis among all socio-economic and environmental dimensions, understanding that there are different values among them (with their respective classification of importance – Cato, 2009); and
- **Process analysis focusing on the impacts pathways and *ex-ante/ex-post* analyses** – To assess innovation impacts mean monitoring every step of the innovation process, from the stages of identifying the demands and needs of clients and stakeholders.). The extension of steps should contemplate from an *ex-ante* impact assessment, to post-innovation impact generation over time (*ex-post* impacts), including impact delays, in society, the economy and the environment.

Seeing Figure 5 (page72), one can verify the external environment involving the entire internal environment where is the core of the innovation system. Interaction, interdependence, and inter-influence are constant between internal and external environment (internal and external systems), as the General Systems Theory advocates (Metherbe, 1986; Law and Kelton, 1991; Buckley, 1976; Bertalanffy, 1968). The external environment, composed of the ecological, social, political and economic dimensions, with its various nuances, produces signals - information inherent to problems, demands, needs and aspirations.

Continuing the analysis of Figure 5, from a systemic view, it can be verified the external information (from market and stakeholders) that will be handled and will be part of the input of the innovation impact assessment system. Information will be added to other input ingredients (people, knowledge, financial resources, partnerships with other organizations etc.). By specifying each step of the system in detail it can check the following components:

- **Input**

The input represents all resources and information necessary to be processed for a research organization to achieve its goals and accomplish its mission.

Inputs are personnel, laws, rules and institutional documentation, budget, new and old necessary knowledge for generating solutions, contracts with partners and clients, social and economic demands and aspirations (including market demands), environmental needs, the institutional and political support, and important information.

This stage will demand a radar and intelligence process to treat data and information as well as a process for capturing all kind of necessary resources that will ensure institutional sustainability. It makes part of the input stage the organization's ability to effectively manage the impact assessment system, as well as behavioral components, which are essential factors for the model's success - integrating holistic vision, constructivist approach and transdisciplinary. This stage must also to identify stakeholders, and creates dialogue/interact with them, as well as classify them in order of importance and direct and indirect influence - in the social, political and economic dimensions, including important research funders, as well as representatives of institutions responsible for environmental issues or activists in this area.

From an ex-ante impact analysis perspective, a prospective analysis of the expected impacts on these stakeholders, supply-chains and the environment, over time and at different degrees of intensity, should be carried out (Kuby, 1999; Metherbe, 1986; Law and Kelton, 1991; Buckley, 1976; Markus et al., 2002; Rodrigues et al., 2010).

- **Processing**

For input processing to be performed, the organization needs to rely on its staff, organizational structure, internal rules and governance processes. It means that organizational units and processes, as well as people, need to be organized, trained and empowered to allow the processor's primary focus to be ready to capture and treat signals from social intelligently (including in this context the cultural and political components), economic and ecological environments. This stage will demand for governance and management ability to achieve positive results and intermediate impacts, which represent important step towards achieving positive final impacts to the innovations (Kuby, 1999; Metherbe, 1986; Law and Kelton, 1991; Buckley, 1976; Markus et al., 2002; Rodrigues et al., 2010).

When resources and information are treated, many intermediate products are generated such as: **policies, strategies, institutional guidelines, organizational structure, research & innovation portfolios, management processes, research and innovation projects, administrative and research activities**. All these products must be aligned with each other and must reflect the needs, demands and aspirations of stakeholders.

During the operationalization of an open innovation system, it must be understood that **it does not mean that there are no rules or criteria for exchanging information along the innovation course**. It is necessary to filter the type of exchange according to each innovation in progress when it is necessary to identify which partners or stakeholders should interact with the innovation and at what time, as well as what is specified in each partnership contract. However, most of the time the process must occur in a constant open information flow of exchange as the environment and its actors, according to the level of importance and influence (direct or indirect) that each one exerts on the innovation, whether political, institutional, budgetary and financial, scientific, social, economic and ecological.

- **Outputs**

Outputs are all kind of knowledge and information generated by the research organization. They are solutions generated by the organization, are all types of knowledge embedded and expressed through scientific information, technology, production system, process, product, prototype, patents, scientific papers and all kind of organizational publication, software, application, training, reports and service

(Kuby, 1999; Metherbe, 1986; Law and Kelton, 1991; Buckley, 1976; Markus et al., 2002; Rodrigues et al., 2010; Alston, Norton and Pardy, 1995).

Information can be diffused by electronic way or paper, in a video, or expressed through lectures, conferences, workshops, seminars, training, field days, during monitoring processes of experiments of given research, including informal dialogues with stakeholders (Kuby, 1999; Metherbe, 1986; Law and Kelton, 1991; Buckley, 1976; Markus et al., 2002; Rodrigues et al., 2010).

A production system comprises several components in a given environment and within a certain time. For example, crop-livestock-forest integration is an innovation based on a productive system. It can involve proper soil preparation, the use of appropriate seeds to the system, by adopting consortium and succession of species, as well as integration of the system's management. It also requires a systemic vision and integrative approach to deal with problems and solutions, thus demanding, at the very least, interdisciplinary and ideally transdisciplinary teams (Embrapa, 2018; Kuby, 1999; Markus et al., 2002).

A process can be understood as methodologies and procedures within a system; it may be a new agronomic or administrative procedure that allows for achieving better final results. Processes are, for example, procedures for generating products, such as processes for obtaining packaging, food, beverages, feed, chemical, biological, industrial (Embrapa, 2018). It can involve a way of specific cultivar plantation or can represent a better way of procedures of technology transfer and diffusion (Embrapa, 2018). It can combine many procedures and techniques in the managerial, agronomic or operational field.

A service can be a new way of doing market research on agricultural technologies or transferring technology to rural technical assistance workers or producers. New ways to do field days with farmers, to create new ways of farmers motivation, new practices of engagement and groups participation (Calbo and Pusinhol, 2017; Embrapa, 2018). Or, in addition, innovative ways of stakeholder engagement in the characterization of demand, in the generation of a solution and the multiplication of rice seeds, the fruit of a new participative process of innovation (Calbo and Pusinhol, 2017). Web services, consulting, workshops, conferences or seminars aiming at interaction with stakeholders to identify problems, demands and aspirations, as well as technological solution dissemination along the value-chain, can be considered produced services as well, among others (Embrapa, 2018).

Meetings, lectures, workshops, field days and other events carried out, aiming at the transfer or sale of solutions, exchange of experience for enlarging and improving the interinstitutional relationship, or even related to construction, implementation or evaluation of public policies, can be understood as other produced services by a research organization (Embrapa, 2018).

Technology transfer is a type of service related to the research organization output (Calbo and Pusinhol, 2017). It is important to emphasize the crucial role of the transfer of technological solutions, which is strictly part of the innovation process since poorly transferred technology can lead to the ruin of all efforts to generate the solution to meet certain problems or research demands (Calbo and Pusinhol, 2017).

Products are technological solutions of a physical and digital nature, such as software, applications, prototypes, video, cultivars (seeds and seedlings), animals, machinery, equipment, beverages, fertilizers, vaccines, publications and others (Embrapa, 2018).

Non-Tangible Outputs or Non-measurable technological solutions, such as a new way of thinking, new knowledge inserted in processes or production systems, or even in the academic knowledge improvement, by meaning a leap of knowledge(Saqib et al., 2015). It is important to point out that a large part of the solutions generated in research organizations fall under this item.

This reality should serve as a warning so that impact assessment processes are not a straitjacket that hinders the creative and innovative process of research teams and even from the initial stages of finding solutions to problems identified in the productive sector or society (stage of demands prospecting, as well as at the setting of research portfolio) (Saqib et al., 2015).

- **Outcomes**

Outcomes are products, technological solutions or services adopted by the customer or user. Outcomes are the outputs absorbed and applied by the productive sector (Kuby, 1999; Metherbe, 1986; Law and Kelton, 1991; Buckley, 1976; Markus et al., 2002; Rodrigues et al., 2010; Alston, Norton and Pardy, 1995). A research organization output transferred to a service of rural technical assistance will be maintained as output until the moment the producer adopts the technical assistance workers to transfer output.

The same logic will be applied in the case of a certain quantity (in ton or kg) of matrix seeds is marketed or passed on to the basic seeds or grains multiplier. The solution in the form of basic seeds will be outcomes when farmers decide to plant them as a final product (it is expected that this product will be directed to consumers). Thus, a total planted area with a specific technological solution can be an outcome metric way for enabling measurement or calculation of consequent impacts (Embrapa, 2018).

It is important to be attentive because the boundaries can be very tenuous between output and outcome, and a degree of relativity between the components along the supply chain must be observed. Monitoring the impact pathway represents a necessary action for collecting data of intermediate and final impacts. Intermediate impacts are effects resulted during the process of innovation that can affect internally the research organization or even its external actors or partners (Markus et al., 2002; Kuby, 1999; Saqib et al., 2015; Douthwaite, 2003; Joly, P. et al., 2016).

Other researchers or other research projects that receive a specific solution it will still be outcome up to its consequence (final solution) be adopted by the producer or supply-chain. Licenses for using a patented solution can also be considered an outcome. It means: registered or patented technological solutions are still in the scope of outputs and become outcomes when occurring their license for customers to use in production systems (agricultural, industrial or service).

Outcomes may also be the number of books or publications sold or even accessed on paper or in electronic form. A prototype will be an outcome when consumers bought the product produced by the industry that acquired the technological solution (Embrapa, 2018). A new management attitude or new technical procedure adopted by the producer or adoption of a new protocol, or even change in producer behavior can also be considered an outcome (Jonkers et al., 2018).

In the new model of Innovation Impact Assessment Management System outcomes are results, not impacts. Sometimes the boundary between output and outcome can be very tenuous and almost imperceptible (Alston, Norton and Pardy, 1995; Douthwaite, 2003; Kuby, 1999), but it is important to delimit these limits well and understand that it is not enough to produce something: the final impacts should always be pursued.

It is not enough to deliver a solution. It is possible that some adopted solutions can come passing by a short-lived of using and provokes users' frustration. In this case, the problem may be related to the technology itself, or failures in the transfer of information and the fragile process of internalization of a certain solution may cause negative impacts in the technology future evaluation. Then, it is important to pay attention to the technology transfer and after adoption, because the outcome stage is a process and not a staged stage, that is, normally not a stagnant step. It is necessary to follow the process of farmer production after he has acquired a technological solution. In trade practice it would be the follow-up after-sale.

It means delivering what has been produced, and based on ethics and respect to the user or customer, to monitor and check (evaluating the process) if the producer has absorbed exactly what one wanted to transfer in relation to knowledge or solution so that the acquirer can use the product, technology or service efficiently.

This process requires client or user follow-up to measure the transfer effectiveness and his degree of satisfaction (this may influence the quality of future impact assessment). Thus, the post-transfer phases of technological solutions should act as a mobilizer and inductor of the research organization so that it creates an organizational process that is responsible to the users or clients follow-up, by monitoring their satisfaction degree throughout the pathway of the innovation adoption (Joly, P. et al., 2016; Douthwaite, 2003).

This is because, the impacts tend to generate delayed effects in the time (Joly, P. et al., 2016; Douthwaite, 2003), generating positive or negative reflexes in the short, medium or long term. So, the phases of adopting a solution will require monitoring, patience, and ongoing analysis by the research organization, which must be attentive to provide corrective actions (Joly, P. et al., 2016; Douthwaite, 2003). It can be related to the improvement of organization-client dialogue, focused on communication troubles, or adjustments of technologies, process or product. Surely, these quick responses will require customers' participation for solving problems, and they must be aware of organization efforts on that (as an organizational resilience mechanism) (Saqib et al., 2015).

It is interesting to note that outcomes often can represent an important step in measuring results of research projects due to the certain levels of indirect impact they can cause to the scientific community, students, generation of solutions, as well as for the dissemination of scientific knowledge to readers and society in general. These fall within the group of results that are difficult to measure or even non-measurable because they are classified as diffuse and therefore non-tangible results (Saqib et al., 2015; Alston, Norton and Pardy, 1995).

Then, this stage can be considered as a pre-impact phase and deserves to be accounted for even to identify the number of products, services, technologies or pre-technologies transferred, or information and publication sold or accessed.

Undoubtedly, in these cases of non-tangible results and open diffuse information spread to the readers and society, the evaluation process will have a qualitative rather than a quantitative character due to difficulties of measuring its impacts under mathematical parameters (Saqib et al., 2015; Alston, Norton and Pardy, 1995).

- **Impacts**

The impact assessment is a systematic and impartial evaluation of an activity, project, strategy, policy, operational area and organizational performance, for example (UNDG, 2011). For this thesis, impacts represent the consequence on the environment, society and economy of what a research organization produces and are absorbed by its users (impact of innovation).

In the case of an agricultural research organization, it is the effects that affect farmers, the productive sector and supply chains. They can also affect user behaviors and influence scientific knowledge and academic training. They have a temporal and spatial scale, that is, they generate effects in the short, medium or long term, or even with perennial consequences (Brian and Palenberg, 2018). They can generate repercussions in the environment, society and the local economy, in the region, country or on a global scale, in different degrees of intensity (Hearn and Buffardi, 2016)

The impacts inherent to outcomes **may be positive or negative** and should be subject to process monitoring, implying checking in the innovation course, which may generate course adjustments, as well as feed the final output and outcome, which will be measured in the *ex-post impact*. **The endpoint of the whole impact management system will be the confrontation between what was planned as a scenario of future impact (*ex-ante* impact) with what was accounted as an *ex-post* impact** (UNDG, 2011; ISRIA, 2017; Ruegg & Feller 2003; Douthwaite et al., 2003). This confrontation of data and information will allow us to adjust policies, strategies, plans, projects and future activities. The result of the analysis of impacts will serve as feedback to the system, that is, it may lead to redesigns in the elements that make up the system input.

Throughout the process, partial solutions are generated that should be monitored and evaluated, aiming for course adjustments when necessary and given the final impacts established as scenarios of future impacts or impact targets (IAI, 2017; Ruegg & Feller 2003; UNDG, 2011; Douthwaite et al., 2003). After the outputs, we arrive at the stage of transferring the solutions to the first customers or users of these solutions, and at that moment the pre-solutions emerge, besides publications as well as events of diffusion and transfer (outcomes).

This same conceptual basis of the relativity theory allows understanding the dynamics and speed of time in this relational interactivity, being able to be longer or shorter according to diverse situations. This framework creates the need to install a fast track or shortcut process. It means a dynamic organizational structure capable of quickly responding to certain environmental stimuli from the nature, society, market, productive chains and consumers, of one or several stakeholders, by proportional speed to what is expected of the reaction to meet the stakeholders' expectations or nature needs (Jonkers et al., 2018).

It is worth noting that the number of article citations is a case of exception in which knowledge can be measured, generating quantitative data for access to knowledge. However, there are cases that just one or more scientific information transferred in field days or a technical visit by technical assistance workers, can generate important impacts on productivity and economic and social gains for the farmers, and can produce positive or negative effects also to the environment (Joly, P. et al., 2016). The simple information about the reduction of a certain spacing between plants and streets in the planting of a certain species can double the productivity and economic return for the farmer.

There are many cases in which the researcher, after observing some experiments, arrives at scientific conclusions without having had time to produce a paper (Joly, P. et al., 2016; UNDG, 2011; Rodrigues et al., 2010). Or even a technical assistance worker can observe that the producers are not adopting a certain agricultural practice that has already been informed but, it has not been internalized. And then at some point of monitoring, it observes the deficiency and reinforces the information producing a positive impact through non-tangible results.

In many cases, tangible or not, impacts will come after a certain time that the outcomes were adopted and then their effects can be monitored and evaluated in the medium and long-term, or even in the short or the perenniality of certain impacts.

1.1. Intrinsic Relationship between the Open Innovation and the Proto-Model

Consistent with innovation characteristics and impact assessment in continuous interrelationship with stakeholders and all components directly and indirectly influential in the process of generating solutions, the Proto-Model (Figure 5, page 73), adopts as theoretical reference the concepts of open innovation[5].

[5] "The use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesbrough et al., 2006).

A research organization can generate technological innovation, product innovation, process innovation, organizational innovation, service innovation, and marketing innovation (Diez, 2001; Hallsted; Thompson and Lindahl, 2013). Global quickness requires systemic reading, in a dynamic and complex environment, in non-linear processes of innovation (Greenacre et al. 2012). It is essential that an invention can arrive at the market, but this is not enough. A feedback loop and a close relationship with the needs and desires of society are also required and denote that innovation is important, while these factors will depend on the impact analysis, sustainability warranty, and longevity (Planing, 2017).

The research process cannot be closed because of the speed and dynamics of information required by organizations to be open for interaction and innovation with partners (Chesbrough et al., 2006). Innovation comes from interactions within a collective of actors that allows the mobilization of different types of knowledge - scientific and non-scientific (Barret et al., 2018).

Based on that, it is essential to research organization implement an advance model of sustainable innovation system (Hallsted; Thompson and Lindahl, 2013) grounded on an intelligent philosophy of open innovation that aims at disruptive or incremental innovation results.

This situation indicates that present research organizations need to redesign their frameworks towards greater flexibility, adaptability, and resilience capacity to a dynamic world which requires a dynamic process of innovation, that interacts with the scientific and non-scientific, market, consumers and society in general and above all that is environmentally responsible.

Great part of public organizations around the world focuses its innovation and impact evaluation processes on economic impact. It is understandable given the public budgets have become increasingly more limited and companies that invest or donate resources for research, generally expect economic returns of the research, or at most, that its outcomes can promote social impacts as the generation of employment and income. In this way, the environmental dimension emerges as an externality or factor that should generate worries and care but rarely constitute priority, except in specific cases of basic research focused on ecological resilience or environmental protection.

It is expected that innovations in the agricultural sector, for example, are connected with markets and social interests, which can boost the economy of the producer, municipality, state and country where the farm is located. That economic impacts can stimulate the supply chain and generate wealth and social welfare. Surely, whether the economic sector is dynamic the tax collection for the government will be increased, and it implicates good possibilities to enlarge the research organizations budget. However, that the opposite way (from the environmental to the social and economic dimension, respectively) should serve as a reference for, at least, constructing a consistent research impact evaluation system to them, because the environment conserved will be exactly the guarantee for a healthy society and a sustainable economy (Cato, 2009).

It is essential that the organization that comes to adopt the model of innovation's impact assessment management system designed in this thesis, implements an open innovation platform that will operate as support for the *ex-ante* and *ex-post* impact analysis. This platform has to be operated by a whole and integrative management system based on the proto-model here considered, which requires a dynamic, holistic and broad interaction with its stakeholders throughout the entire innovation process. This thesis will not address or detail this platform, however, it will demonstrate a basic architecture of open innovation, which should guide the construction of the new model of innovation impact assessment.

1.2. The Proto-Model and Necessary Behavioral Components

Figure 5 (page 727373) indicates the behavioral components, as described in the literature review, such as constructivism, holism, transdisciplinarity as well as management ability. They are essential aspects of success in interrelational processes between internal and external environments, between the various players in the innovation process and those who participate in the impact assessment process. If the general theory of systems represents the theoretical framework that supports the proto-model, the behavioral factors allow the functioning of this gear to operate in a salutary and effective way. After all, building innovations and assessing their impacts presupposes dealing with people, who demand respect for and opportunities to feel heard or as direct or indirect co-authors of innovations as well as active members of the stages of impact assessment of these innovations (Bradberry, 2018).

Governing and integrating a team of the innovation process and innovation impact management require a series of attributes related to the behavioral approaches, and appropriate knowledge, skill in social mobilization and stakeholders engagement, while will require well qualified transdisciplinary teams. It is necessary to have not only knowledge or rational intelligence, but, also, emotional intelligence. Emotional intelligence is "something" in each of us that is a bit intangible. It affects how we manage behavior, navigates social complexities, and make personal decisions to achieve positive results" (Bradberry, 2018).

Current management practices should be considered when adopting constructivism in processes of innovation and impact assessment to be conducted by a research organization (but also important when adopting the concepts of holism and transdisciplinarity). It is recommended the agile leadership as a management way of success, which takes an approach based on encouraging the mobilization and effective engagement, collaboration and high level of communication among the actors involved in the innovation and evaluation process, without communication barriers between bosses and subordinates, which often act as obstacles when there is no climate of trust and interpersonal respect. This approach considers motivational practices that provide high efficiency and effectiveness of project teams and to construct an impact assessment culture (CLW, 2017).

Whether a research organization develops an impact assessment culture among its employees, partners and customers, it tends to mature organizational awareness about the importance of monitoring and self-assessment and in some way, that experience tends to reflect as positive feedback. When adopting a constructivist, holistic and transdisciplinary process, the organization will probably be more mature to absorb the impact evaluation culture during the process of technological innovation (Joly, P. et al., 2016; Douthwaite, 2003).

In order to build the impact culture within the research organization and among stakeholders, monitoring and evaluating the innovation process along its pathway is an essential attitude, either in the internal pathway (within the organization, when measuring partial or intermediate impact), or outside the organization (during *ex-post* assessment). It reflects the insertion of the behavioral concept along the innovation and evaluation processes (Joly, P. et al., 2016; Douthwaite, 2003).

2. Case Study of Four Research Organizations: observations and conclusion

The comparative analysis of the four organizations (Cirad, Inra, Embrapa and CSIRO) methodologies related to research impact assessment was an important stage of this thesis. The case studies adopted 8 variables as parameters of analysis:

- connection with institutional policies and strategies;
- the existence of framework to evaluate the innovation's impact;
- connection with the innovation process of the organization;
- insertion of the constructivist vision in the actors' attitude during the operationalization of the process of impact assessment;
- adoption of concepts and practices of holism;
- adoption of the principles and practices of transdisciplinarity;
- adoption of the concepts of sustainability by a cross-cut view; and
- process analysis focusing on the impacts pathways.

The proposal here is to make a comparison among the research organizations experiences and demonstrated some convergent or complementary factors among them, and, in other aspects, it exposed positive points and gaps or weakness in all methodologies. For example, about the socio-behavioral question, in Cirad methodology were identified four important and linked aspects: constructivism, training and participatory process as a process for developing a culture of impact assessment. Focusing on the specific issue of a systemic approach to research impact assessment, another exclusivity of the Cirad methodology was the insertion of ex-ante and ex-post evaluations, although both are not interconnected by a single system of monitoring, management and results in comparison.

The commitment of top management to the impact assessment process and connection between the organization's policies and strategies with the impact assessment process were identified in all methodologies. A fixed organizational unit with a permanent research impact assessment team and a tactical approach for this evaluation were observed in Embrapa and CSIRO methodologies. An operational approach for impact assessment was observed in Cirad, Inra and Embrapa methodologies. Social, economic and environmental dimensions clearly stated and measured in the impact assessment report of all four organizations analyzed.

It is important to highlight that Embrapa's methodology is indeed divided into two methodological instruments: Social Balance Report and Ambitec-Agro. The first one is a tactical approach regarding the hierarchy scale of the structure and the second one to the operational level. Mixing both methodological instruments, it is observable that Embrapa's methodology has socioenvironmental and economic indicators with a high level of detail inserting factors such as employment, income, internal rate of return, quality of life, quality of water and soil, atmosphere, levels of contamination in the natural environment among others.

Cirad, Inra and Embrapa impact assessment methodologies have citations about impacts over supply chains, but they have not deepened analysis on that approach. It is CSIRO methodology exclusivity to considers a wide involvement of production supply-chains in the evaluation process as well as the insertion of the political dimension which denotes a high engagement of stakeholders, and conduction of evaluation process by an external and independent organization. Cirad also has positive stakeholders' engagement along its evaluation process.

Insertion of the policy dimension into the impact assessment process was the exclusivity of Embrapa methodology, although CSIRO clearly considers a component related to political aspects as an important reference for the economic sustainability of the institution. A strong focus on the impact pathway along the evaluation process analysis, despite Embrapa, considers that the Cirad and CSIRO have emphasized more methodologically it. The connection between the organization's impact assessment report and the superior court of public auditing for accountability and transparency is the exclusivity of Embrapa methodology.

It is important to highlight the CSIRO model represented in the design of its simplified and self-explanatory research impact assessment system, which demonstrates the various input, processing, output and impact components, although the model does not include clearly points of interaction with the external environment, with the respective connections with the stakeholders.

As essential points for the success of innovation's impact assessment models, hereafter are describe the eight main variables for comparative analysis of the four research organizations, indicating or not the tuning among such reference bases (according to the literature) and each research organization analyzed:

- Connection with institutional policies and strategies;
- The existence of a framework for impact assessment;
- Connection with the process of innovation;
- The process of innovation and impact assessment process under the constructivism concept;
- The process of innovation and impact assessment process under the holism concept;
- The process of innovation and impact assessment process under the transdisciplinarity concept;
- Sustainability by a cross-cut perspective; and
- Process analysis by viewing the impact pathway perspective and e*x-ante*/*ex-post* analysis.

Connection with Institutional Policies and Strategies, (EEA, 2001; Verheem 2002; Barros de Mendonca & Laques 2017; IAI, 2017)

Cirad Case

In this case, it is important to separate the impress methodological design of the connection among Cirad institutional policies from the impact evaluation process. When analyzing the consulted documents (cited in the literature review in this paper), it is not clear that there is a logical and systemic connection between the Impress (*ex-ante* and *ex-post*) methodology and a unified document encompassing this one within a systemic, consequent and institutional policy, despite the institutional documents affirming the importance of Impress. Impress is a method for evaluating the operational impacts of adopted technologies by stakeholders (Cirad, 2017; Cirad, 2016).

Inra Case

Although the institutional documents affirming the importance of ASIRPA, it was not possible to identify any institutional strategy linked to research impact evaluation as part of its strategic plan - *Alliance nationale de recherche pour l'environnement* (Inra, 2016), and linked to institutional policies by a systemic process. ASIRPA represents a specific project to analyze operational research impacts (Inra, 2017). Social Balance is an annually published set of information about its personnel and its internal social policy, without an impact analysis on the society – available to the external public (Inra, 2015).

Embrapa Case

The Strategic Plan of Embrapa cites the axis of impacts as an important reference for orientating strategic actions; however, there is no impact goal or a specific systemic line integrating a management system for impact evaluation coupled with the innovation system that could converge to *ex-ante* impact the evaluation and impact goals to be measured. There is an evaluation system called Integro (Integrated Performance Management System: Institutional, Programmatic and Team) that is used to assess research, organization and team results, which means it is used to measure efforts and efficacy, not impact (Embrapa, 2018). *Ex-post* impact evaluations are made by specific models of the tactical impact level through an annual Social Balance Report and on the operational impact level through Ambitec-Agro. Then, Embrapa's approach has a relative connection between institutional policies and the process of impact evaluation.

CSIRO Case

"If we are going to stay on the cutting edge and deliver solutions for real-world problems, we need to bring impact thinking to everything we do" (CSIRO, 2017; CSIRO, 2015). The CSIRO Corporate Plan 2017-18 is an annual tactical document (CSIRO, 2017;

CSIRO, 2015), based on its strategic and multiannual plan – called Australia's Innovation Catalyst – CSIRO 2020 (CSIRO, 2017). In all of these documents the CSIRO Research Impact Assessment is inserted and described, which demonstrates a positive interconnection among them and with the Methodological Guide of Impact Evaluation. Thus, by its documents, it is possible to verify a logical link from the policy and strategic level up to the tactical and operational level, permeated by the impact evaluation view and goals.

The Existence of a Framework for Impact Assessment (EEA, 2001; Verheem 2002; Barros de Mendonca & Laques, 2017; IAI 2017)

<u>Cirad Case</u>

The process is supported by specific strategic projects and case studies, with temporary staff and budget for each project, and there is not a continuous framework, or at least there is not a fixed and structured managerial process for impact evaluation (Barret et al., 2018; Cirad, 2017; Cirad, 2016).

<u>Inra Case</u>

This process is supported by specific strategic projects and case studies, with temporary staff and budget for each project, and there is not a fixed framework, or at least, there is not a structured managerial process for impact assessment (Inra, 2017).

<u>Embrapa Case</u>

There is a continuous and specific structure for the impact evaluation process, for both tactical impact evaluation (SBR) and operational evaluation (Ambitec-Agro). There is an organizational unit for evaluation linked to the Secretariat for Institutional Development, with a fixed team continuously working on this issue. Embrapa's Research Centre for the Environment has a specific team for Ambitec-Agro. This team represents an important advance compared to the INRA and CIRAD experiences, as well as some similarity with the CSIRO framework (Embrapa, 2018).

<u>CSIRO Case</u>

CSIRO has a fixed and continuous structure, team, and infrastructure specialized for impact assessment called the Performance and Evaluation Unit (CSIRO, 2015).

Connection with the Process of Innovation (Schumpeter, 1983; Greenacre et al. 2012; Ruttan 2001; Planing 2017; Chesbrough et al. 2006; Pisano et al. 2015; Barret et al., 2018; Hallsted, Thompson and Lindahl, 2013; Diez, 2001; Walker, 2007; von Schomberg, 2012).

<u>Cirad Case</u>

By following dynamic and current innovation concepts, Cirad considers that innovation can be defined as a new product, process, new way of accessing services or a new way of trading its products or services; all with a technical, organizational, institutional and social focus (Barret et al., 2018). It is a positive vision of innovation from the impact pathway perspective, and there is some connection between the institutional innovation system and the impact evaluation process. There is no clear specification about the connection between the institutional innovation system and the impact evaluation process.

<u>Inra Case</u>

Although it places a low emphasis on it, Inra's methodology sometimes cites impact analysis from the innovation perspective, especially because of Inra's adoption of the pathway principle. There is no clear specification about the connection between the institutional innovation system and the impact evaluation process.

<u>Embrapa Case</u>

There are references and correlations among SBR and Ambitec-Agro with the innovation process, but both methodologies were not coupled to an organizational innovation system that directly tied the innovation system to an impact evaluation system, and there is no deepening of innovation's concepts in either methodology.

<u>CSIRO Case</u>

At many points throughout the text of CSIRO's impact guide (CSIRO, 2015), and in other strategic and tactical documents, there are remarks about innovation as an important aspect or goal to be reached, but the innovation system is not coupled to the impact evaluation process.

The Process of Innovation and Impact Assessment Process under the Constructivism Concept (Gatherer 2010; Freeman 2005; Morin 1990; Morin & Le Moigne 2003; Piaget 1967; Vygotsky, 1978; Naylor & Keogh, 1999; Brooks & Brooks, 1993)

Cirad Case

Major player integration in the innovation process and along the *ex-ante* and *ex-post* impact analysis represents an important aspect of the constructivism concept inserted into the Cirad method. This theoretical insertion is also highlighted during the learning processes of different actors (researchers, farmers, producer organizations, etc.) by the impact pathway with an emphasis on constructing an organizational culture of impact (Cirad, 2015). An evaluation process carried out by an external and independent organization would be advisable.

Inra Case

Upon analyzing the steps of the Inra methodology, there was not a clear insertion of constructivism concept. An evaluation process carried out by an external and independent organization would be advisable.

Embrapa Case

In the Embrapa methodologies, there is no citation of the concepts of constructivism concept, even though Ambitec-Agro has significant farmer participation during its evaluation process. Embrapa's process is driven by the internal team, though there is some client consultation. An evaluation process carried out by an external and independent organization would be advisable.

CSIRO Case

Nowhere in the CSIRO methodology was there any citation about constructivism concept, although wide participation of external actors propitiates a rich constructivism process, which is still enriched with the external and independent organization that drives the impact evaluation process. This external participation offers high reliability to the information and data collected during the process (CSIRO, 2015; CSIRO, 2017).

The Process of Innovation and Impact Assessment Process under the Holism Concept (Jonkers et al., 2018; Mulej et al., 2006; Morin & Le Moigne, 2003; Gatherer 2010; Caon 1998; Iribarry 2001; Oliveira et al., 2018)

Cirad Case

There are citations in the impact assessment system of this institution regarding the importance of a holistic view. The process of constructing an innovation and evaluating its impacts brings an approach with components of a holistic approach (especially when it is mentioned the importance of non-scientists participation along the process as well as the wide participation of external actors) (Cirad, 2015).

Inra Case

This institution takes full account of the holistic view in the parts concerning principles that outline its impact assessment system, without deepening this concept on the implementation stages of its system.

When referring to project impact analysis, there can be some bias and loss of quality of impact or weakness in data reliability because researchers integrate most project analysts. Inra considers that 77% of the knowledge generated resulted from the contribution of the external partners such as in terms of physical and biological infrastructure (Inra, 2017). In this sense, considering the concept of holism, wider stakeholder participation during the impact assessment process is advisable.

Embrapa Case

The processes that compose the impact assessment system of this institution, in its two approaches (Ambitec-Agro and Social Balance) do not clearly address the concept of holism in its methodologies.

<u>CSIRO Case</u>

It was not possible to identify a clear insertion of the holism's concept in the system of impact assessment of this institution.

The Process of Innovation and Impact Assessment Process under the Transdisciplinarity Concept (Zscheischler, 2018; Guattari, 2015; Gatherer 2010; Freeman 2005; Caon 1998; Iribarry 2001; Oliveira et al., 2018; Morin, 1990; Cohen and Lloyd, 2014; Hadorn and Pohl, 2007; Scholz et al., 2000; Mutz, Bornmann & Daniel 2015)

<u>Cirad Case</u>

There is no clear citation on a transdisciplinary approach in this institution's impact assessment system. Although environmental, social and economic dimensions are mentioned, they are treated in a segmented way, with a strong emphasis on the economic and social dimension on the environmental dimension. The political dimension is not addressed.

<u>Inra Case</u>

There is no clear citation on a transdisciplinary approach in this institution's impact assessment system. Although environmental, social and economic dimensions are mentioned, they are treated in a segmented way, with a strong emphasis on the economic and social dimension on the environmental dimension. For example, ASIRPA considers the territorial dimension to be interconnected with the social dimension, and the sanitary dimension to be another independent component related to animal and vegetal health. There is a strong emphasis on agronomic approach in its model. The political **dimension is not addressed.**

<u>Embrapa Case</u>

There is no clear citation on a transdisciplinary approach in this institution's impact assessment system. Although environmental, social and economic dimensions are mentioned, they are treated in a relative segmented way. This institution has the closest approach of a transdisciplinary concept, although there is no systematic methodology for transdisciplinarity development along the process. The political dimension is not addressed, although some consideration is addressed on public policies interface, with goals achieved.

CSIRO Case

There is no clear citation on a transdisciplinary approach in this institution's impact assessment system. Although environmental, social, political and economic dimensions are mentioned, they are treated in a segmented way.

Sustainability by a Cross-Cut Perspective (UN, 1987; UN, 1992; UN, 2010; Mendonca, 2016; Cato, 2009).

Cirad Case

There is some connection among their strategic initiatives and the Sustainable Development Goals (SDG) of the United Nations, which are reflected in the inclusion of the Impress as part of their research impacts. However, even though environmental, economic and social components are cited, some discrepancy or unbalance arises among these three dimensions, which shows the absence of ideal synchronicity with sustainable development principles and the definition stated by the UN. A strong emphasis on the economic (included agronomic aspects) and social components are noted in the methodology (UN, 1987).

Inra Case

In the strategic documents of Inra, the Sustainable Development Goals are emphasized in the impact evaluation process (Inra, 2016b). In some projects, the environmental dimension is also considered regarding impact evaluation, particularly the biodiversity and ecological balance aspects. The synthetic graphic is important for demonstrating the sustainability of impact behavior, with its quantitative score that presents a kind of sustainability balance for each analyzed project, although the methodology has not explored this dimension. By analyzing the impact context of Inra’s research on the analyzed projects, in general, the economic impact is mainly visible, and after that comes the environmental, then the social, territorial and health dimensions.

Embrapa Case

No citations or direct correlations were identified between the Embrapa methodologies and the UN SDG. However, the three dimensions considered in the conceptual scope of the united nations are contemplated in the methodologies adopted by Embrapa. In both methodological cases, SBR and Ambitec-Agro are regarded in the social, economic and environmental dimensions. At the tactical level of information, SBR makes some citations related to a sustainability dimension by integrating all three dimensions simultaneously. In this aspect, the SBR approach demonstrates some advantage if compared with other organizations (Cirad, Inra and CSIRO) because of its transversal sustainability approach. Ambitec-Agro has a deep and detailed social and environmental approach, at the operational level of information, with specific indicators on these issues. However, different from the SBR methodology, the Ambitec-Agro economic dimension could be more complete.

CSIRO Case

The CSIRO impact assessment model does not make a direct and emphatic correlation with the United Nations Sustainable Development Goals. However, in the impact categories item, sustainability is cited as an important dimension to be evaluated related to the consumption and production systems. It is very clear that CSIRO method emphasizes economic and political impacts more than social and environmental impacts, and this is observable in highlights concerning funders and stakeholders and demonstrating transparency and positive returns on investments applied to the research. A sustainability approach from a cross-cut view is considered to be important to CSIRO in the scope of the economic category but not in the separated dimension of an environmental component, although there are specific categories for economic, environmental and social dimensions (CSIRO, 2015; CSIRO, 2017).

Process Analysis by Viewing the Impact Pathway Perspective and *Ex-Ante*/*Ex-Post* Analysis (Douthway et al., 2003).

Cirad Case

The process for evaluation consists of five steps: drawing the case study, confronting the actors, constructing the story of innovation and the impact pathway, characterizing and measuring impacts and validating with the actors (Cirad, 2015; Cirad, 2016).

An important aspect observed in the Impress methodology is monitoring the action that occurs in the innovation process with a direct impact (producers, researchers, for instance) or indirect impact (scaling out, scaling up and spillover). All this detailed information captured along the pathway demonstrates the great acuity and positive approach of this methodology. Another important observation is about *ex-ante* and *ex-post* considered analysis in its methodology, although both stages are not viewed by a systemic approach and managed by a unique linked management system (Cirad, 2017; Cirad, 2015).

<u>Inra Case</u>

ASIRPA's method is marked by the basic theory of systems, namely, input (knowledge, personnel, resources, institutional partnerships, etc.), output (research results), intermediate impacts (related to administrative, marketing, regulatory and other solutions not concerned with research activities but important to the innovation process), first impacts (related to first users of innovation), and second impacts (reflects general innovation users, with effects to economy, society, territory, health and environment) (Inra, 2016). This method represents the interesting and wide consideration of the components of the impact pathway.

The methodology steps are:

- Case Selection;
- Chronology (length of the research, investment needs, partners' capacity);
- Pathway (construction of the trajectory between research and impact, appraisal of the different actor contributions and external context analysis); and
- Impact Radar (which consists of monitoring the various impact dimensions, including economic, environmental, social, territorial and health) (INRA 2016a). The radar focus denotes the sharp and interesting emphasis on follow-up during each step of impact.

<u>Embrapa Case</u>

Although Embrapa does not emphasize the impact pathway as a relevant methodological aspect, this organization supports its approach to impact steps by focusing on the *ex-post* impacts.

As part of its impact content, SBR has the following institutional indicators: basis of calculation and economic indicators (net revenue, operating income, economic surplus, internal rate of return and gross payroll); internal social indicators (food, compulsory social charges, private pension, health, occupational safety and health, education, culture, training and professional development, daycare, the results sharing, and others); external social indicators (education, culture, health and sanitation, combating hunger and food security, and others); and environmental indicators (investments related to the production/operation of the company, investments and external projects, and total investment in the environment).

Social profit is an important measure verified in SBR methodology, representing the balance between research investments and social returns. Specific qualitative and quantitative impact indicators are referred to as a means of analyzing three success cases of technological solutions generated by each of Embrapa's research centers.

Ambitec-Agro is an *ex-post* system applied to all of Embrapa's research centers and adaptable for technological solution evaluation, as well as rural activity performance evaluations, by using a set of social and environmental criteria and indicators and by scaling up the generating of quantitative measures and qualitative analyses (Rodrigues et al., 2003).

The scale used for evaluation follows a specific check-list with an integrated vision of social and environmental dimensions, varying from -15 (maximum negative impact) to +15 (maximum positive impact). Impacts are evaluated according to three spatial scales: nearer environment, proximate environment and the surrounding environment. Ambitec-Agro evaluates environmental quality based on the quality of the atmosphere, water, soil and biodiversity conservation, as well as natural habitat restoration and quality of the agricultural product. From the social perspective food security, employment generation and quality, income, health, and other indicators are evaluated (Rodrigues et al., 2010).

It would be interesting if farmers and technology users, as well as other actors along the supply chain, could conduct their technology evaluation as Cirad does.

CSIRO Case

Although CSIRO does not emphasize the impact pathway in its methodology, this institution adopts a methodology that considers all steps of impact evaluation and closely involves stakeholders during the consultation process, clearly defining who they are and their level of influence on research sustainability and its impacts.

The CSIRO methodology is based on the strategic and tactical levels, concentrating its impact analysis on research programs. Therefore, CSIRO's research program offers national economic, social and environmental impacts by providing scientific solutions, information and advice (CSIRO, 2017; CSIRO, 2015).

In Table 1, based on eight variables, a summary of the observations and conclusions can be verified from the analysis of the four research organizations studied.

Table 1. Variables for Comparative Analysis of Four Organizations

Variables	Cirad	Inra	Embrapa	CSIRO
Connection with institutional policies and strategies	-	-	Partially	Fully
The existence of a framework for impact assessment	Temporary framework	Temporary framework	Permanent framework	Permanent framework
Connection with the process of innovation	Partially	Partially	Partially	Partially
The process of innovation and impact assessment process under the constructivism concept	Fully	-	-	Partially
The process of innovation and impact assessment process under the holism concept	Partially	Partially	-	-
The process of innovation and impact assessment process under the transdisciplinarity concept	-	-	-	-
Sustainability by a cross-cut perspective	-	-	Partially	Partially
Process analysis by viewing the impact pathway perspective and *ex-ante*/*ex-post* analysis.	Partially	Partially	Partially	Partially

Table 1, above, summarizes the degree of an interface between each of the eight variables and the innovation impact assessment system of each research institution, considering that this degree is variable and can be absent, indicated with a dash (-), partially or fully. It can be observed that each institution has different or convergent characteristics among them. The transdisciplinary approach was the only parameter that found no resonance in any of the institutions. Cirad and CSIRO were the only ones that achieved the degree of fully of alignment. The degree "partially" was the most frequent (twelve times) among all institutions.

2.1. Field Experience as a Test Opportunity for Some Survey Tools

The new model of impact evaluation system designed in this thesis has in the field survey an opportunity to test some tools of data collection, together with on-site observations on the agricultural areas that adopt Embrapa's technologies. This study has also to capture perceptions or impressions of the consulted actors. As a final product, it expects to obtain field experience to later propose the most suitable tools for data and information capture to compose the new system model of innovation impact assessment.

It is important to explain here why this fieldwork was focused on Embrapa's stakeholders.

Four research organizations had their innovation impact assessment systems under review, but for reasons of resource-constrained strategy and facilities offered by Embrapa teams, it was decided to choose only one institution (Embrapa) and a sample of their stakeholders to test the field survey instruments.

Embrapa is the agricultural research organization of the Brazil, which represents one of the most important agribusiness players in the world, and what best represents the adoption of tropical agriculture technologies, with significant impacts on production in the market of grains, meats and biofuels.

It is important to highlight that all these analyses were restricted over survey tools adopted by Embrapa's models (Social Balance Report and Ambitec-Agro). The field experience brought valuable contributions regarding survey tools, for constructing the new model of the impact assessment system. Tools were tested, for example, for capturing stakeholders' opinion and their results were important to confront some inferences about several social-economic and environmental information collected in the field versus information that was inserted in the Embrapa's Social Balance Report 2017. It was also possible to check in field reports (by confronting reality and secondary data) the quality of the result of Ambitec-Agro methodology after its application.

It was possible to observe and check congruence between fieldwork results versus Social Balance Report 2017 and Ambitec-Agro methodology on impact assessment. Both approaches have a broad spectrum of data and important results, especially about the measurement of socio-environmental and economic impacts of the use of soil, and effects in the quality of life and income of the farmer who adopts a technological solution (the ABC[6] Plan technological solutions were the studied references).

It was important to hear partners and clients, to capture how they see the research, how innovations benefit them, identifying troubles and challenges related to the links and stages among the innovation process, technology transfer and technical assistance by identifying gaps between planning and practical world, and especially analyzing data and information coming directly from the grassroots. In fact, these results represent peripheral information whether we regard to the model of innovation's impact assessment management system as a whole, but they have important details to a fine adjustment of the survey tools that integrate the model.

It is important to describe an important observation and learning from the field experience. The formalities during interviews demonstrated that they create self-protection of interviewees, generating a dissimulation ambiance, while they can omit or lie about some information. To the new model of innovation's impact assessment is recommendable to adopt a wide spectrum of interview tools based on the semi-structured and unstructured instruments, and also interviewer has to be prepared regarding skill for this kind of approach.

During stakeholders interviews, also with researchers and at some moments of interventions in experimental fields within producers' properties, despite the easy interlocution between these actors, it was not possible to observe the adoption of concepts of holism, constructivism, and transdisciplinarity among them and into the Embrapa's methodology of data collection.

These moments of interaction could be further expanded in interaction with other stakeholders such as rural technical assistance workers, a representative of the financial institution that manages rural credit, representatives of productive sector organizations, private research organizations, universities, representatives of agro-industries and all members of supply chain related to the innovation under analysis.

[6] It is a brazilian public policy focused to agricultural production and its reduction of carbon emission (Mapa, 2018).

The internalization of a culture of broad interaction with stakeholders would help in the future an impact assessment process with an equally participative and interactive methodology not only for constructing the innovation, but also during the impact evaluation process.

The collected information in the field has detected problems related to technology transfer (there are knowledge gaps among researchers, private rural assistance workers and producers). The learning of this experience for the new model demonstrated how important a constructivist, holistic and transdisciplinary approach is during the innovation and impact assessment processes.

Other aspects were observed resulted from the use of geotechnologies which demonstrated how they are important tools to evaluate the innovations impacts that affect the natural and altered landscape, in Brazilian case, given the environmental legislation that protects riparian forests and other natural reserves. Thus, this tool represents great support for assessing environmental impacts and should be considered in the tool roll of the innovation impact assessment model to be built on this thesis. However, it is not enough.

Among ten visited farms, in three it was verified non-compliance with the environmental law. Although the satellite images have indicated the correct existence and conservation of the permanent preservation areas in the farm, during farm visit it was locally observed many cattle accessing that environmental reservation. Animals have accessed that local by under big and medium trees. Satellite images identified the reservation was intact. Thus, it did not identify the real situation under those trees. By the law, the access of cattle to this environmental reserve is forbidden.

This observation and on-site verification may represent marginal data within the majority of landowners who fully comply with the law of Brazilian Forest Code but may indicate that 30% of state farms are not by environmental legislation and this would merit quantitative research to validate this hypothesis. Another important finding is that only satellite images are not able to prove that the farm is fully in compliance with environmental legislation.

This confirmation suggests that an impact assessment methodology to be applied in Brazil, to verify the level of sustainability of the landscape taking as a parameter the Forest

Code, should consider in its analysis of data not only satellite images but also, visits and on the spot verification, by samplings.

In addition to these tools, it was observed the importance of using structured interviews, local collection of data by an external and independent organization, especially for capturing environmental data, as well as stakeholders' opinions and secondary data.

The details of the data, the results, the analysis and the conclusions of the field experience (**Annex 1**), the georeferenced images of the region and localities visited (**Annex 2**) and the models of the interview script (**Annex 3**) are attached.

3. Benchmarking: useful aspects for the model that were captured in the four organizations

3.1. Designing a Basic Model Reference as Benchmarking

The figure below represents a grade of advance besides the proto-model towards an ideal new model of innovation's impact assessment system, and demonstrates a basic reference inspired in the four research organizations, especially in CSIRO experience which is tuned with literature review and the proto-model. This model will reinforce the new model of impact assessment for evaluating the research and innovation production.

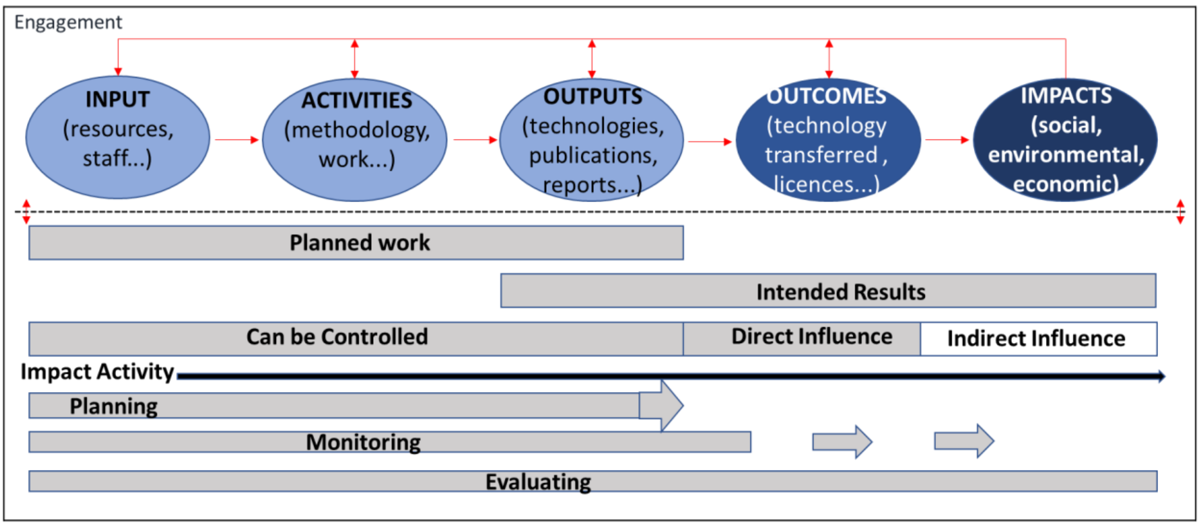


Figure 6. CSIRO's Impact Framework (Adapted from W.K. Kellogg Foundation, apud CSIRO, 2015)

The above Figure 6 shows an integrated connection among each stage of evaluation system by considering input, process, outputs, outcomes, and impact while an innovation perspective is simultaneously visible in the same figure. This model allows a broad view of the management process, making it clear where to insert effective control points on the variables that make up the internal and external scenario, contemplating all stakeholders. It facilitates the identification of risks, barriers, fragile points and propellers of the relations with the actors, evaluating the degree of impact, whether they are direct or indirect and their dimension in the timescale. There was a gap, however, in the spatial scale of impacts that the model does not indicate.

This design experience to demonstrate an integrated system will be as an important conceptual base for a new model in the designing process in this thesis.

3.2. Some Important Tools Captured from Field Experience: applicable to a new impact assessment model

This item is directly related to 2.1. item.

According to the basic concept of benchmarking, it is not enough to absorb or to be inspired by the positive points of other organizations, it is also necessary to identify gaps or possibilities to give an upgrade on the experience of others. Then, by observing positive aspects of the believable studied methodologies of benchmarking, as well as with data and information verified in the field, it was possible to identify important gaps and methodological weaknesses, which in the end, will feed the new model to be designed, aiming to achieve an improved system.

By concluding on the tools analyses used and observed during field experience, it is recommendable for a new model of innovation impact assessment:

- it is indispensable local technical surveys focused on environmental components (directed on water resources and its quality, the quality of soil, biodiversity conservation, and landscape that can mix natural landscape with productive landscape which must include social, economic and cultural aspects);
- use of geotechnologies associated with local observation;
- adoption of semi-structured and even unstructured interviews; and

- the assessment process has to be driven by an external and independent organization, without the interference of the research organization that is under the evaluation process (even this organization has developed the methodology).

All detailed data, results, analysis and tools adopted during field experience are attached as annexes.

3.3. Other Experiences Captured from Research Organizations plus Upgrade

In line with the benchmarking concepts that compose the literature review, this item sought to summarize other important points found in the experiences of the four research organizations complementing aspects that could be improved.

3.3.1. Considering the Open Innovation Concepts by Viewing Innovation Impact Assessment

The new model of innovation impact assessment management system absorbed the positive points of the research organizations methodologies studied, associating the theoretical aspects more comprehensively and deeply from the point of view of reaching impacts by a cross-cut vision of sustainability of what the research organizations produce in pre-technologies, technologies, services, processes and products.

An efficient and effective model of an agricultural innovation impact assessment system should be supported and overlapped on an open innovation system, where the process of identifying social and economic demands and desires as well as environmental needs should provide broad stakeholder engagement, integrating current scenarios and future trends. And it is not enough that broad participation is restricted to the initial stage of identification and selection of demands and needs, it is essential that all stages of innovation the system is sufficiently open to interact with stakeholders. The Cirad's and CSIRO's impact assessment systems have important references regarding the open innovation concepts and close correlation from this one and impact assessment process.

It is clear in Cirad’s experience engagement and broad interaction of actors in identifying problems and generating innovation through training, workshops, and meetings, inserting in this context constructivist principles, which will be reflected in the stages of evaluation and the construction of a culture of impact among the internal team and stakeholders.

3.3.2. Considering Open and Continuous Interaction with Stakeholders

It becomes necessary that identification and characterization of stakeholders are according to the degree of direct and indirect influence of each stakeholder, the level of their political or knowledge impacts on the innovation process and this characterization will signalize when and where they will be interacting with the various stages of innovation.

It is also worth mentioning another positive aspect identified in the Cirad methodology, which is the proposal of a broad interaction between scientific and non-scientific segments, understanding that the generation of knowledge and solutions require mental opening of the internal actors and certain organization of the innovation system for allowing exchange of knowledge and experience among all actors. Contemporarily speaking, the innovation cannot be understood as one exclusive property of researchers, except in specific cases of a closed contractual relationship between clients and research organization.

This analysis leads us to the conclusion that for an impact assessment system to be successful, it is previously necessary to develop an open innovation platform in line with the most current practices of agile and collaborative leadership, ensuring a broad actors engagement, from the beginning up to the end of the innovation process. It will be essential to enable the impact assessment to be carried out in the track of the various innovation stages, following the impact pathway over the innovation pathway, up to the outcomes, and finally reaching the *ex-post* impacts, allowing them to be evaluated and confronted with predicted *ex-ante* impact.

3.3.3. Considering the Ex-Ante Impacts

Ex-ante impacts will be measured pre-emptively (in the form of forecasting of impact future scenarios) through the innovation pathway, assessing the intermediate or partial impacts of innovation by specific measurement mechanisms, without losing sight of the final predicted impacts, which should be used as sign to final goals as reference of environmental, social, economic and political impacts.

This integrative vision of *ex-ante* evaluation connected with *ex-post* evaluation leads us automatically to think of a unique governance solution of the impact assessment, that is, it implies building a management system of impact evaluation that will visualize the *ex-ante* stage and *ex-post* in an articulated and coordinated way. Cirad's methodology is the only one among the four organizations that address the *ex-ante* impact assessment.

Cirad's experience indicates a positive approach in terms of *ex-ante* impacts, although it is unclear how it is monitored and managed, including how *ex-ante* evaluation is systematically connected to *ex-post* impacts, given the important confrontation or comparative analysis between the was predicted and what happened in the real world.

3.3.4. Considering Impact Aspects that Should be Measured

All four organizations make considerations about impact scales and other impact characteristics but by a not systemic point of view, which means that considers spatial scale (including supply chain as the ways for accessing several locals, state, regional and global markets) and temporal scale, as well as aspects of intensity and others seen from a systemic and linked perspective.

The blend of important aspects captured from four research organizations experiences to be considered in an impact assessment system are the mechanisms of measuring the scale of impact: spatial (local, regional, world), temporal (short, mid and long-term) and intensity (low, medium and high). A system may be restricted to certain limits, however, it should ideally include all, especially when it is a country that has exported agriculture and high impact in the internal market. It means that technology that impacts production and therefore certain products that will be moving along productive chains will have an impact on the course of this value chain and can reach global markets. At the same time, there are certain locally produced impacts, such as those related to the emission of carbon that results from the productive system into the farm, which somehow immediately contributes to the process of global climate change.

3.3.5. Considering Impacts from a Sustainability and Transversality View

A concept of the transversality of the sustainability dimension, according to Cato's (2009) approach, demonstrates that the environmental component should overlap with the social, and this, in turn, with the economic component. The political can be understood as within the social component. This view of classification because of importance induces the establishment of important weights at the time of the impact assessment. It means that if a solution generates a high positive economic impact, but, if it has a high negative environmental impact, there should be a reduction factor in the overall impact.

The research organizations studied make primarily analysis and reports focused on the operational and tactical level. None organization makes a strategic consolidation and respective strategic report. The Embrapa's process generates operational analysis and a tactical report with some strategic points inserted on it. To say whether a process and report are strategic or tactical depends on the defined scope setting its limits. But, in this thesis, a strategic process and strategic report are considered that one which should directly influence the review of scenarios, policies and strategies in a systematic way.

On the other hand, it is important to note that Embrapa makes a report on the operational impact with a strong emphasis on the environmental and social components and the report on the social balance (tactical, with a management report profile) the three components are looked: environmental, social and economic, with some considerations on policy analysis. It implicates that there is a connection between operational and tactical data towards a tactical consolidation.

Ideally, the impact evaluation system should be capable of analyzing and exposing reports at the operational, tactical and strategic levels, all interconnected, which means that has to exist the direct connection from operational data to tactical and this one to the strategic level, including their analysis and reports in a systematic way.

As a way of safeguarding the impartiality of the process and thus guaranteeing the reliability of information throughout the various stages of the impact assessment, it is recommended that an external and independent company conducts the process. The research organization should guide the methodology to be applied, but its application should be carried out impartially, as CSIRO has been positively adopting in its experience.

3.3.6. Considering Behavioral Factors

Other important aspects to be considered in an ideal impact assessment system are the behavioral components as the insertion of holism, constructivism (previously mentioned), transdisciplinarity and leadership capability. These are essential for stimulating, motivating, mobilizing and engaging internal and external actors during the innovation and impact evaluation processes.

The reading of the social, economic, and ecological environment is done through people, although technological tools and equipment help us as instruments. And this is repeated when the demands and needs of producers, supply-chain, research partners, technical assistance and rural extension, consumers and society as a whole are identified. This process will go on through the innovation stages and along the impact assessment pathway. It means that such reading cannot be carried out under a harsh look at reality, without insight, without psychological preparation, and without essential elements for collaborative, agile and effective leadership.

Engaging stakeholders in innovation processes and research impact assessment is a challenge of constant effort as well as the continuous development of the ability to lead successfully. Thus, other important aspects to be considered in an ideal impact assessment system are the behavioral components with the insertion of concepts of holism, constructivism (previously mentioned), transdisciplinarity (at least interdisciplinarity) and leadership capability. These are essential for engaging internal and external actors along the innovation and impact evaluation processes.

Cirad's experience has an important example of holism and constructivism practices. The CSIRO's one has a relative insertion of holism concepts, like Embrapa as well.

3.3.7. Considering an Approach about the Audience

Based on CSIRO (2015; ISRIA, 2017) approaches Table 2, below, captures a set of four impact intentions related to specific purposes and audiences of an ideal model to be constructed: Accountability, Allocation, Analysis and Advocacy.

Table 2. Purposes and Audiences of Impacts

Purpose	Specification	Audience
Accountability	Be clear and transparent to stakeholders, funders and society in general, demonstrating responsibility in the use of resources to reach outputs, outcomes and impacts, as planned.	Supreme Auditing Institution, government control bodies, financer organizations, federal organizations of supervision, society in general.
Allocation	To be an instrument of governance and management when using impact analysis such	Research organization top managers, projects and

	as feedback and policy adjustments and priorities in research and innovation investments. It is intended to be a tool to support the decision-making in meeting the society and stakeholders' interests, monitoring and re-evaluating plans, portfolios and research projects, and organizational processes, by searching the best solutions for the mission fulfillment and strategic institutional goals.	processes leaders, internal teams.
Analysis	To be an instrument of impact culture development and of sustainability impacts analysis, with a transversal view of the economic, political, social and environmental dimensions, identifying the reasons for failures, gaps, and successes of outcomes, as well as transforming these results as learning, deepening of maturity and resilience of innovation teams, by constructing the organization continuous improvement attitudes.	Internal teams of the research organization: managers, projects and processes leaders, researchers, analysts, technicians.
Advocacy	Demonstrate the importance and benefits of innovation for the various users and clients of the research organization, attending to the different niches of interest and direct and indirect beneficiaries.	Stakeholders: partners, clients, users of technological solutions, consumers.

Summarizing the Benchmarking Practice Towards The New Conceptual Model of Innovation's Impact Assessment Management System (positive points absorbed from four analyzed institutions plus upgrade on their systems of impact assessment), we can see the key ideas in Table 3, below:

Table 3. Main Contributions to be Inserted in the Proto-Model towards a New Model of Impact Assessment

Variables	Other Indispensable Principles, Structural and Behavioral Aspects To Be Considered
1. Connection with institutional policies and strategies.	+ To be aligned with the UN Sustainable Development Goals, in particular Goal 2 and 12. + To be in tune with the society's demands and aspirations (including economic and political components), with ecological conservation needs and environmental resilience. +To be transparent in the construction and implementation of policies, strategies, innovation projects and organizational processes, up to reach of outputs, outcomes and impacts, by demonstrating to the stakeholders, financiers and society the return of investments.
2. The existence of a framework to assess the	+ To adopt a permanent structure for assessing impacts, with continuous and

innovation's impact.	trained teams, financial and material resources.
3. Connection with the innovation process of the organization.	+ To adopt an Open Innovation Architecture (and after a detailed Open Innovation Platform) as a basic requirement to be coupled with the impact assessment process. + To adopt a wide and continuous interaction/dialogue with stakeholders.
4. The process of innovation and impact assessment process under the constructivism concept. 5. The process of innovation and impact assessment process under the holism concept. 6. The process of innovation and impact assessment process under the transdisciplinarity concept.	+ To be sure that there is a wide internal and external actors participation during the innovation process and impact assessment process, as well as all stakeholders capability by continuous training, workshops, meetings and informal and open dialogue, by aiming to construct trustful climate and respect among them and between the internal coordinators and other actors. + To be sure that scientists and non-scientists are integrated and in tune during the innovation process and along the process of impact evaluation. + To be sure that the analysis process of the impact assessment must be impartial, it means, it has to be driven by an independent and external organization. + To be sure that all disciplines (that interface with the theme in discussion and construction) are represented in the innovation's and impact assessment teams, and whether there are events to develop synergy, empathy and open dialogue among all actors.
7. Adoption of the concepts of sustainability by a cross-cut view.	+ To consider the sustainability dimension of impacts by integrating economic, political, social and environmental components through a transversality perspective. + To avoid segmentation among all considered dimensions, and see all of them by a unique managerial perspective, making efforts to insert each dimension within the another during the analysis process.
8. Process analysis focusing on the impacts of pathways and *ex-ante*/ex-post impacts.	+ To understand that the system will be focused on impacts pathways analysis (within and outside of the research organization, by considering during planning process, it means forecasting *ex-ante* impacts, as well as after outcomes stage, it means assessing *ex-post* impacts). + To insert a whole and integrated managerial system of research impact assessment, covering as an "umbrella", the *ex-ante* and *ex-post* impacts. + To consider impacts measuring aspects as timescale, spatial scale, length of impacts, the intensity of impacts.

4. The Final Conceptual Model of Innovation Impact Assessment Management System (IIAMS), by a Sustainability Cross-Cut Perspective

4.1. General Overview of the Model

The new model developed in this thesis absorbed concepts of literature review, several important approaches and relevant experiences of four studied research organizations, as well as to fill out gaps not considered by these organizations and indicates a systemic view by inserting a governance and management system of impact assessment, by adopting principles of benchmarking. This system searches to be synchronized with a research innovation process and recommends that the external and independent organization must drive the assessment process.

The Conceptual Model of **Innovation's Impact Assessment Management System – IIAMS** designed here, despite being adapted to other types of research organizations, **will be especially directed to agricultural research organizations** and starts from a macro systemic approach towards micro approaches, that is, starting from a general model and then decomposing into specific analysis of its parts.

IIAMS could be based on existing innovation processes in any of the research organizations studied in this thesis, however, the proposal is to search for a model that is closest to the set of positive points found in theoretical review and institutions methodologies studied. In this way, it becomes essential to make benchmarking and, consequently, propose an innovative model tuned with the **philosophical framework** as drawn in Table 2 (page 110).

Synthetically, what is the purpose of assessing impacts and what are their audiences?

IIAMS can reach a large spectrum of purposes and audiences, but it is mainly directed to a synthesized group of objectives, according to Table 2 specifications. It means considering the four impacts intentions:

- Accountability (to be transparent, comply with demands to oversight bodies and supervision of public resources and society in general);

- Allocation (to be an instrument of governance and management for an organization's managers);
- Analysis (to be an internal team instrument of continuous improvement of the impact assessment process and innovation's process, by a cross-cut view of sustainability); and
- Advocacy (to demonstrate the importance of innovation for stakeholders).

What is the IIAMS Model?

IIAMS is a system that aims to manage the impact assessment process of a research organization, under the focus of sustainability and predominantly geared towards the agricultural sector. The agricultural sector is here understood as part of supply chains before, during and after rural property, involving chains linked to agriculture, livestock, forestry, and aquaculture sector as well as multifunctionality of farms, activities related to the rural development on sustainable bases, and also industries and services related to these sectors. IIAMS is based on the **guiding thread fixed in Table 2, page 110.**

IIAMS is a governance and management tool in support of decision making. By means of feedback on the impacts that innovations cause and listening to its stakeholders, it helps to adjust policies, strategic plans, research and innovation projects, and organizational processes.

IIAMS is a system that visualizes and coordinates *ex-ante* (forecast of impact scenarios) and *ex-post* assessments (both impacts, *ex-ante* and *ex-post*, focused on the social, political, economic and environmental reality) in an integrated way and within a unique and interacting management approach. **The system is based on the impact pathway, which is coupled with the innovation process course. And it goes beyond outcomes stage** since it seeks to follow impact pathways in the economic, social, political and ecological environment, by tracking the various space and time scales, considering the delays of time. After technological solution adoption, it is normal the existence of delay time for the impacts is manifested.

IIAMS is a system composed of several parts or processes by interrelating, interacting and inter-influencing among them. This general theory of systems is the groundwork that will guide the general concept of impact assessment system as well as a proposed open innovation model (Buckley, 1976; Geyer and Zouwen, 1992; Japiassu and Marcondes, 1989; Bertalanffy, 1968). Thus, as part of the impact assessment management system, **there is an evaluation of intermediate impacts, ranging from the identification phase of the society demands (productive sector and other stakeholders) up to the initial phase of the outputs. Then there is the evaluation of the outputs stage, of the outcomes and then the assessment of the *ex-post* impacts happen**. The evaluation of intermediate impacts is, in fact, processes evaluation throughout the innovation course. However, it is now called the intermediate impact assessment for creating, fixing **and expanding the impact culture within the research organization and with the various internal and external actors.**

Within each innovation stage, there will be "gateways" of impact, within which will be used management tools to evaluate intermediate impacts, also to evaluate outputs and outcomes. The *ex-post* evaluation phase will also have appropriate management tools. All these tools will be described in detail in the item on the Framework and Operation of the System.

4.2. Defining Innovation by the IIAMS Approach

As mentioned previously, an innovation impact assessment model must be coupled to the innovation system because the evaluation will measure the impacts of what the research organization produces for its stakeholders, market and society. Thus, focusing on the ultimate goal of this thesis, it is essential to understand the concept of innovation, its types, its characteristics and its architecture in the context of IIAMS.

Innovation is the process of inserting changes to something established by introducing something new; it means introducing novelty or improvement in the productive or social environment. Innovation is the connection between the demands and aspirations of society and the economy, as well as the needs of environmental resilience, with the human and organizational capacity to identify and treat these demands, wants and needs and to generate creative solutions to meet them (O’Sullivan, 2008).

Innovation is not just about inventing, which is an important step in the process, and it is not just connecting inventions to the market; it's more than that. It requires the ability to read the social, economic, political, cultural and ecological environment (O’Sullivan, 2008).

By synthesizing, and within the IIAMS and open innovation context: **innovation is the outcome effectively acquired, transferred and absorbed by the users and clients resulted from the interaction, tuning and continuous exchange between stakeholders and the research organization**.

Understanding the innovation characteristics, there are eight innovation's categories and three types of innovation. **The innovation categories are:** pre-technological innovation, technological innovation, product innovation, process innovation, system innovation, service innovation, organizational innovation, and marketing innovation.

The types of innovation are: **incremental** (which promotes small improvements or advances in existing solutions, which means no less important than other innovations), **radical** (highly innovative creation); and **disruptive** (that breaks paradigm).

By understanding this thesis, the market concept is inserted in the context of the economy, and this, in turn, is inserted in society. In this way, the market here has a broad understanding, far beyond what some people usually understand, which reduces its concept only to big business environments. **The market will be understood as the demands of the society and economic system**, respectively. It means the whole environment where a solution and its effects are acquired and absorbed up to the final consumer, comprising large, medium, small or micro producers or businesses, that is, any size or extension of arrangement and production chain or market (Cato, 2009).

4.3. The Innovation Architecture Definition

The ideal would be to construct a detailed innovation platform that must be suggested to future research. **Then, it is not intended here to develop a complete and detailed innovation platform, but just an architecture of the innovation platform to create a frame or basic track where the model of the research impact assessment system can be supported and then carry out its analysis.**

Innovation comes from interactions within a collective of actors that allows the mobilization of different types of knowledge - scientific and non-scientific (Barret et al., 2018). Innovation based on wide social comprehension understands that society drives the economy and is interested in the environment, and thereby creates a link among all these components, including the sustainable development agenda (Pisano et al., 2015).

Then, the innovation definition here is based on a systemic reading, on a dynamic and complex environment and on non-linear processes (Greenacre et al. 2012). The research process cannot be closed because of the speed and dynamics of information require organizations to be open for interaction and innovation with partners (Chesbrough et al., 2006).

As mentioned earlier, it is essentially the building of the impact assessment model within a framework or skeleton of open innovation, which here is called the Innovation Architecture. It will be imperative that, in the future, when an organization comes to adopt this methodology of impact assessment, this architecture will deploy to an open innovation platform or in a detailed open innovation system.

This innovation's architecture is a theoretical reference for the IIAMS, and it is based on Figure 5 (page 73, the Proto-Model) and the general theory of systems, and adopts as basic principles:

- All innovation will adopt ethical principles, respect for the environment, to the society and the laws in force related to the subject;
- The innovation process will take as its primary goal to help the UN to meet its sustainable development goals, in what be within its action scope;
- The innovation process will be opened, subject to contractual commitments or partnerships that establishes confidentiality or varying degrees of restriction, implying open interaction only between persons and researchers authorized by the respective contract or term of the partnership, according to each case;
- The innovation process, including all its stages, will have a high level of stakeholder engagement;
- The innovation process will be permeated, in all its stages, by the principles and concepts of sustainability, including the stages of impact evaluation, to guarantee the management of what is generated during the life cycle of the products inserted in diverse production chains and the ecological, social, political and economic environments;

- The innovation process will insert concepts of constructivism, holism, and transdisciplinarity as a way of guaranteeing effectiveness in the engagement of all stakeholders, by considering scientists and non-scientists throughout the innovation stages, according to each case or information exchange needs;
- The innovation process will adopt principles and practices of collaborative and agile leadership, to develop advanced management practices, focused simultaneously on the process, results, and impacts, by understanding that the human being is the motivational center and guarantees the achievement of the desired goals; and
- The innovation process will continuously stimulate the creativity of the internal and external actors of the research organization, in parallel with the innovative focus.

4.4. IIAMS as a Tool for Governance and Management, and its Components

4.4.1. IIAMS as a Tool for Governance and Management

The innovation's impact assessment management system has a governance role connected with the commitments to society, of environmental responsibility and promoter of economic sustainability, with accountability, establishing mechanisms for management to facilitate to reach the impact goals and institutional sustainability.

Therefore, in this thesis governance represents an interrelationship process between the research organization and its external environment (representative groups and people of society, economy, ecology), which will demand appropriate instrument for linking actors to each other, as structures, processes, resources and staff. Thus, IIAMS is a tool for helping the governance bodies (as top managers) better meet the society demands/aspirations and environment need of resilience, by constructing and adjusting policies and strategies of innovation.

In this thesis, management represents the process of internal driving of the research organization, with appropriate structure, processes, resources and staff, by answering with efficiency, efficacy and effectivity the governance and external environmental demands/aspirations and needs. Then, IIAMS is a managerial tool for helping managers in constructing and adjusting priorities of research & innovation, leading innovation projects and processes of innovation support.

4.4.2. IIAMS Components

IIAMS consists of the following components: Principles, Values of the Impact, Defining Impact Dimensions, Impact's Indicators Parameters, Nature of the Impact or Impact Classification, Impact Characteristics, Impact Intensity, Impact Scales, Level of Impacts, Frequency of the Impact, Impact Relevance.

4.4.2.1. IIAMS General Principles

- IIAMS must be connected with the institutional policies and strategies, and will be aligned with United Nations Sustainable Development Goals, in particular 2 and 12;
- IIAMS must be in connection and with synchronicity with the innovation process of the organization, that will consider an open innovation architecture;
- IIAMS will adopt the process analysis focused on the impact pathway viewing the *ex-ante* and *ex-post* impacts within a systemic perspective of management;
- IIAMS have to adopt sustainability concepts by a cross-cut view, by integrating economic, political, social and environmental dimensions;
- IIAMS will implement a permanent framework for assessing innovation's impacts;
- IIAMS will insert concepts and practices of constructivism, by adopting mechanisms for motivating a participative process with external and internal actors, with even interaction with stakeholders;
- IIAMS will adopt concepts and practices of holism before, during and after all innovation's steps and along the impact assessment process, with transdisciplinary teams, including decision-makers, scientists and non-scientists; and
- IIAMS will adopt impartiality mechanisms for driving the impact assessment process, which means an external and independent entity for conducting the

process, despite the research organization has developed the methodology to be used on that.

4.4.2.2. Values of the Impact

Impacts Have Tangible Values and Non-Tangible Values (Worth)

There are measurable and non-measurable values. There are some types of impacts that cannot be measured by the mathematical vision because they are beyond economic values or even no based on environmental quantitative measurements. Economic values are measurable and cultural or social values cannot be measured, because they are intangible. They can be immersed in an extensive complexity, as in the case of biodiversity in general (within a diffuse, complex and broad ecosystem context). Or even they cannot be measured because they represent an expression of cultural, spiritual or social values (worth) in the broad sense of citizenship, well-being and self-fulfillment. In some cases, it is possible to quantify some aspects of socio-cultural and environmental values. However, even if we attempt to measure or transform them into economic values, they will not be enough, all values (worths) will not be included in their totality what they represent considering historical, anthropological, cultural, spiritual, quality of life, happiness and to some cases of environmental resilience.

4.4.2.3. Defining Impact Dimensions: environmental, social, political and economic

Environmental impacts are all those that affect the internal and external environment of the property where a particular solution was adopted, that means, several spatial scales directly or indirectly affected by the use of such a solution. For example, the carbon balance resulting from the use of the solution, which can directly affect the global climate; the use of certain chemical products that can directly affect the physical quality of the soil of the farm, and indirectly the chemical and biological quality, as well as the groundwater table, and it can also affect the regional hydric basin. Or reflexes to the local and regional biodiversity and landscape. Environmental effects can also occur along the supply chain, such as those related to the product lifecycle (before, during and after productive processing, in the post-harvest period and in the value chain), the energy and carbon balances, or even those related to the generation of solid waste and effluents locally or through the productive-chain.

Social Impacts can be understood as all effects arising from a solution that affects the local, state, national and global social environment, within productive arrangements or productive chains, quality of life, nutrition and health, well-being, the cultural component and other impacts that directly or indirectly affect consumers. Improvement of the quality of life of the farmer's family, improvement in the level of nutrition and general health of this family and consumers indirectly affected by a given research solution.

Political and Policy Impacts will be considered in this theme. So, although in the title is cited only the word Political (for simplification), is cited important to make their conceptual differences. **Policy Impact** as a structural approach refers to public policies, such as economic policy, tax policy, social policy, health policy, environmental policy, etc., and all its derivatives, that is, plans, programs, projects and activities. Thus, impact in this perspective means monitoring the implementation of these policies and assessing their impact after implementation, verifying the extent of what was expected as impact targets and how much was achieved in society, the economy, and the environment. In this context, institutional policies related to agricultural production and research and innovation for the sector are included as well.

On the other hand, **Political Impact** as a process means the evaluation of political discourse, of the way of governing, that is, it considers the behavioral aspects of the policy-maker or manager during the process of construction, implementation and management of public policies or even policies of a company or non- governmental organization.

In this context, the behavioral aspect of a research institution manager (whether public or private) will be crucial for the achievement of policies, strategies, portfolios, projects, processes and activities. Good policy or a well-designed project may not have the expected reach regarding results and impacts if there is no preparation and skill of the manager to coordinate the construction, implementation, monitoring, and evaluation of institutional policies, research and innovation projects. Here it must be considered the importance of collaborative and agile leadership by adopting managerial and behavioral tools as a guarantee for organizational mission success and effectiveness.

Economic Impact can be understood as the production technology affecting the farmer production and hence generates positive or negative impacts on his economy (for instance: improvement of his profitability, improvement in the purchasing capacity of inputs for his production). Another kind of economic impacts are the reflexes on the productive chain to which the product or products generated by the farmer has affecting, and its consequence to the GDP of the municipality, state or country, and effects on consumers and economies of other countries that imported and purchased the product.

4.4.2.4. Impact's Indicators Parameters (defining the scope/ limits of the impacts)

By measuring impact, it is necessary to establish indicators parameters related to the previous situation and after the adoption of a certain solution. This comparative analysis will allow establishing the difference between the two moments: before and after a technological solution is adopted by the farmer or productive sector. In this context, one must be aware that in many cases an impact is due to the sum or interaction between several factors, arising from different origins and different moments. This ambience can make complex the exact identification of a given solution on the environmental, social and economic impact while it is inserted inside a diffused context as a mosaic of inter-influences, interdependences, interactions and in chain effects.

Despite of that, it is important to identify the different origins and times related to different impact causes in a certain environment, supply chain, social group, local country's GNP (Gross Domestic Product), and all type of aspects related to the impact.

4.4.2.5. Natures of the Impact or Impact Classification

The impact manifests itself in several ways. IIAMS classifies the nature of impact in: Quality and Types or Timing.

Quality of impact can be defined as positive or negative. Sometimes a product or technology can be positive by economic dimension and negative by environmental dimension. It is necessary a scale to identify the quality of impact. Moreover, it cannot be restricted to exclusive negative or positive, but, within a specific scale, it can be more or less positive or negative. However, **every assessment process should adopt transparency as a major principle.**

4.4.2.6. **Types of Impact Assessment or The Timing of Impact Assessment**

They are expressed by two moments: the ***ex-ante*** and ***ex-post***. ***Ex-ante* is the impact measured in a visionary way, it represents a prospective or preventive attitude**, that is, resulting from a visualization exercise of a future impact scenario (a forecast). For example, what economic, political, social and environmental impacts the innovation project "x" can generate? This type of impact assessment must be projected throughout the innovation chain, allowing the visualization, the forecast and planning of intermediate impacts goals along each innovation step, and projecting the desired or expected final impacts, which can also be called **final goals of impact**.

The *ex-post* impact assessment occurs after the research organization generates the outcomes. It is retrospective and corresponds to the measurement of the effects on factual reality. This measurement will implicate monitoring and evaluation of the final impacts: from the first customers and users of the innovation up to the last beneficiaries or members of the supply chain or chain of value that come to receive any level of impact. These *ex-post* impacts should measure the effects on the economy, politics, society, and environment.

4.4.2.7. Impact Characteristics

It can be **intended or unintended; intermediate or final.** Before arriving at the producer, a technological solution underwent tests and validation. However, it is possible that, when arriving in the field, and on a large scale, it will generate foreseen or unforeseen impacts, that is, unintentional impacts. Unintentional impacts can also be considered externalities, that is, when a solution is adopted and it generates undesirable or even desirable effects that were not foreseen on the third party (for example, on the economy, society or the environment).

Intermediate impacts are those that occur during the stages of innovation until they reach the outcomes, which will be the last stage of intermediary evaluation. **From the outcomes, the final impact evaluation begins, that is: begins the *ex-post* stage, until reaching the stages of impact unfolded assessment**, which can reach different productive chains over time.

4.4.2.8. Impact Intensity

The impact intensity represents the strength level or intensity of impact, whether low, medium or high intensity.

With the use of a **scale ranging from -3 to +3** it will be possible to merge two impact characteristics: the level of intensity and the quality of the impact. The scale will be -3 the most negative, -2 the average negative, -1 the less negative, the 0 level (without relevant impact negative or positive), +1 with a low positive impact, +2 the average positive impact and +3 with a high positive impact.

4.4.2.9. Impact Scales

The impact scale concerns the extent of the impact, which has two dimensions: time and space. Under a **timescale perspective, there are impacts of short, medium, long, very long-term and perennial impact**. In this component it is necessary to consider lag impacts, which means the impact length along the time: many impact types can delay causing effects to the economy, politics, society or environment.

A short-term impact is one that occurs immediately up to one year. The mid-term impact is more than one year, up to five years. The long-term impact is more than five years, up to twenty years. The extreme long-term impact is more than 20 years, up to 100 years. A perennial or persistent impact means that one over a hundred years and can persist continuously. During the impact assessment process (both *ex-ante* and *ex-post*) it is crucial to take into account the type of technological innovation that is being generated. Some solutions will only generate effective impacts after 20 or 30 years, for instance, ones related to the forestry technologies; while there are others that by 5 years already reach the peak of their effects, like that related to vegetables or grains. And these positive or even negative effects can last for many more years. The literature and experiences of other organizations, such as CSIRO, demonstrate the faster impacts on stakeholders and supply chains when the innovation process is participatory, especially that one concerned to economic and social dimensions. Figure 7 below shows this reality.

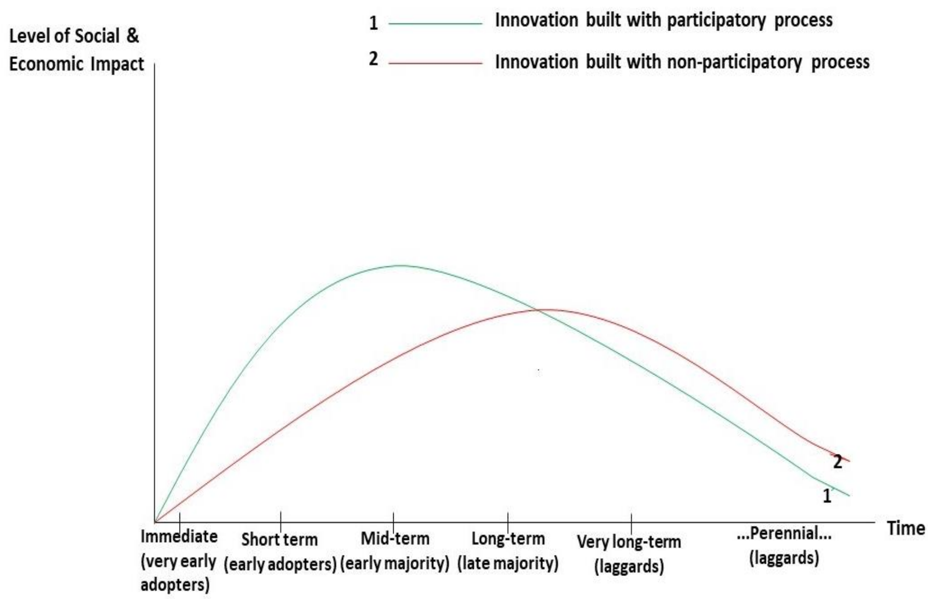


Figure 7. The Scale of Impact Adoption over Time (Adapted from Roger, 1995)

Analyzing Figure 7, above, it can be verified that the solution generation and its maturation time, concerning its adoption (thus becoming an outcome via technology transfer), has a time delay, which can be faster or slower according to the strategy adopted in its construction process. It can be seen, then, that these dynamics provide more immediate answers when the innovation generation occurs in articulation with the stakeholders, with their clients and users. Thus, it is natural that their impacts, especially in the social and economic fields, occur more rapidly. It is noticed that the innovation curve without the participatory process leads to generate its effects over time, extending the impact delay.

The impact on the spatial scale perspective means the geographic space where the effect of a product or service occurs (reflexes of a technological solution adoption). It can be local space (inside the farm); municipality space; state or regional space; country space and international space (even global). Usually, local impacts are impacts inside the farm which have direct impacts on the environment, the economy and the social factors of the producer (for example, health, education and quality of life).

4.4.3.0. Level of Impacts

They can be direct, indirect and unfolded (generating unfolding sequences or chain effects in different supply chains). Direct impacts are the first level; the indirect ones are the second level and unfolded are the third level.

Direct and Indirect Impacts

The direct impact is the direct effect on someone or something. Usually, direct impacts occur on the direct users of a certain solution. It is the direct effect on a farm and his/her owner causing economic and social reflexes, including in the environment. **Indirect impacts are those arising after direct impacts.** Normally, indirect impacts occur on indirect users**. Unfolded impact or chain effect is one that affects a productive chain different from the one that was directly related to the original product, being able to cause a chain effect with outspread on different industrial, service and consumer supply chain**. Generally, unfolded impacts occur on the beneficiaries (consumers or a third party) of a certain solution.

For example, new technology has been adopted by a farmer, that is, a new corn crop cultivar, more resistant to pests and diseases, with the higher level of protein and without increasing the production cost if compared with previous technology. The **new solution generated an economic, positive and direct impact on producer profitability**. This product was used by the industry that produces the canned corn, with lower final price, generating a positive **indirect economic impact for agro-industry.** This corn variety has more protein and helps improve the nutrition of many consumers, generating a **positive indirect social impact (on consumer health**). This corn variety, because of its good texture, attractive color, good taste and lower price than the others available in the market, will be acquired by a chain of fast food which will include it in its menu, generating an **unfolded impact given the unfolding of a new productive chain, that is, a personalized logistic service of canned corn delivery**. Another unfolded impact can be understood as the positive effect to a certain public policy of health due reduction of diseases caused by pesticide contaminations and consequent fewer expenses for farmers with lung intoxication and neurological problems due to contact with these chemicals.

The unfolded impacts

These types of impacts are those with successive effect in productive chains different from that initially related to the product generated from the use of a certain technology. That is, after a given technology has an impact on indirect effects in a certain productive chain, these effects can expand to other production chains. They can be called tertiary impacts, which may arise in the short, medium or long-term (secondary impacts are indirect, and primary impacts are direct). It is important to emphasize that in these tertiary impacts, these should be measured in the economic, political, social and environmental dimensions in different supply chains or businesses that can be generated according to the time elapsed.

4.4.3.1. Frequency of the Impact

The frequency of impact is an important measure for those to discern about the risks and damages levels to the ones potentially or actually were affected by the impact. This measure should serve as a parameter for decision-making in relation to preventive measures (in the case of *ex-ante* evaluation) or corrective or minimizing measures for *ex-post* evaluation. The frequency can be:

- **Constant**
- **Recurring (Intermittent)**
- **One-offs**
- **Variable and Inconstant**
- **Unpredictable**

4.4.3.2. Impact Relevance (on people, sectors or environment)

Often an impact does not deserve so much concern because of its low relevance, or at least it requires less focused attention compared to other more impactful. Thus, a high relevance impact (or even medium) should merit attention and preventive measures (in the case of *ex-ante* evaluation), as well as corrective or minimizing measures (in the case of *ex-post* evaluation). The relevance classification serves as a benchmark of decision-making prioritization for intervention or preventive action. The impact relevance depends on the vision or feeling of who is potentially or actually affected, whether it is a public, a productive sector, part of society, or the environment representative members (for instance, scientists and environmental activists).

From the Perspective of Stakeholders and the Economic, Political and Social Sectors[7]

[7]

- High impact relevance for all stakeholders and sectors
- High only for some stakeholders or sectors (detail)
- Medium for all
- Medium for some stakeholders or sectors (detail)
- Low for all
- Low for some stakeholders or sectors (detail)

To the environmental dimension, the impact relevance will be measured according to the following indicators:

- **High** (specify the component)
- **Medium** (specify the component)
- **Low** (specify the component)

4.5. Sustainability Concepts and Behavioral Approaches Throughout the Process of Impact Assessment

A deep and consistent awareness in fulfillment of the UN sustainable development goals should impel all actors to develop a sustainability culture within the organization and throughout the innovation course and impact assessment. Attachment to this purpose, coupled with the impregnation of appropriate behavioral postures by the managers, project leaders, teams and all stakeholders becomes a crucial point for the IIAMS success. The achievement of IIAMS expected results are closely tied to aggregating, sharing, respect, and interpersonal cooperation postures of the leaders and projects members, as essential conditions to effectively engage internal and external actors.

All steps of the innovation process must be permeated by a holistic, transdisciplinary and constructivist approach, beyond agile leadership concepts, which presupposes that there is full interaction with the internal and external actors as well as operating as a motivational mechanism to develop the impact culture and open innovation attitude among

---

Economic: productive sector in general or specifically segments of producers, industry, commerce, supply chains ...; **Political**: policy-makers, government institutions, parliament, judiciary ...; **Social**: local, regional or national populations, specific social groups, families of producers, traditional populations...

all. The holistic, constructivist, transdisciplinary and agile leadership behavior during the construction of innovation will help create the impact culture among actors, and this behavior must remain during the process of intermediate and final impact assessment.

4.6. The Model of Innovation's Impact Assessment Management System - IIAMS

Figure 8, below, demonstrates the core of the thesis by presenting the summarized model of the impact management system of innovation, by showing the general impacts and interrelationship among its elements, indicating the system basic flows.

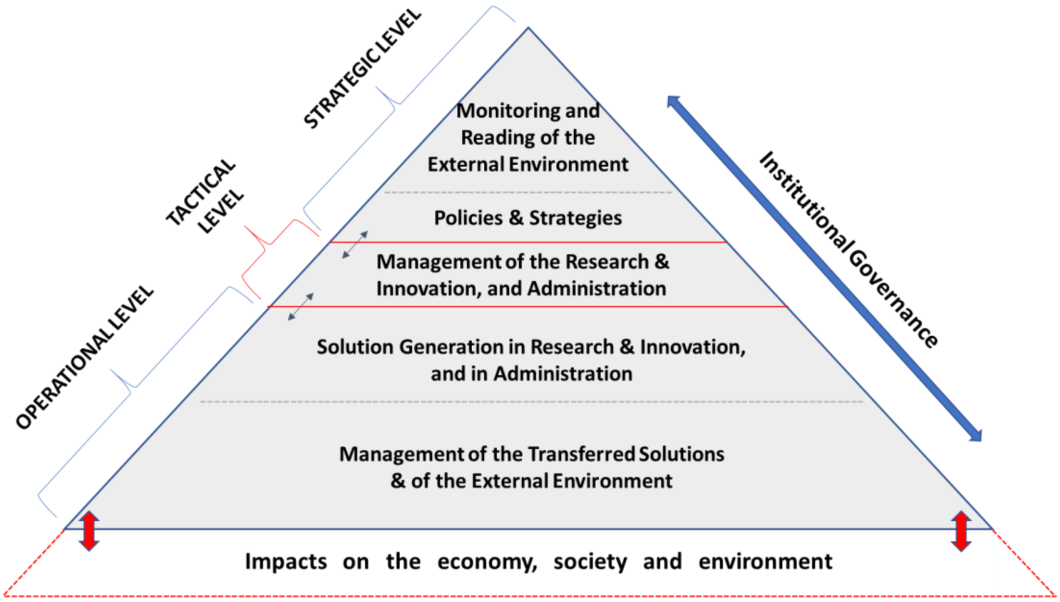


Figure 8. Summarized model of the impact management system of innovation

The strategic level of the research and innovation organization makes the reading of the external environment and establishes policies and guidelines for research & innovation and to the administration. These both processes demand continuous dialogue with stakeholders. At this level, the major *ex-ante* impact goals or expected impacts by the research organization are established (strategic impacts forecast).

At the tactical level of the organization, executive management of research & innovation and administration takes place, based on the policies and strategies defined by the strategic level (top management). Based on the strategic impact goals, this level defines the innovation portfolios of projects and the large management processes. At this level, projects portfolios impact goals (or to the major innovation programs) are established.

At the operational level, research projects and management processes are organized and developed, as well as the expected solutions (outputs) and their outcomes or results, when the technological innovations are accomplished. Innovation management should also occur in this level in the post-transfer of the solution (similar to what happens in post-sales in the case of products or technologies commercialization). It requires monitoring the users or clients satisfaction, as well as evaluating all kinds of impact on the external environment (by considering all stakeholders, economy, society and ecological environment).

Summarizing the descriptive analysis of the IIAMS, it can be said that there are five major steps: reading the external environment; elaboration of policies and guidelines; generation of solutions in innovation; adoption of solutions; and finally the impact stage. The impact pathways occur within the research organization (even if there is interaction with the external environment), generating intermediary impacts, and outside the organization, generating direct, indirect, and unfolded impacts, where the pathways are more complex and therefore, by requiring more comprehensive and complex approaches regarding monitoring and evaluation.

This monitoring and evaluation should include environmental analysis, from the economic, political and social context, and should involve as many stakeholders as possible, which should be classified in order of importance versus direct or indirect influence on the institution, its outputs and outcomes. These measures will be reflected in the quality and degree of institutional sustainability.

We can observe in Figure 8 above, the continuous flows among all stages of the innovation pathway, demonstrating the interdependence and interaction among their components. It is also clear the impacts along the course of innovation and along the supply chains, which may affect to a greater or lesser degree the different members of the external environment (stakeholders, users, customers), as well as the environment itself, with repercussions on society and economy. IIAMS consists of 18 large blocks, which may represent strategic processes in the superior part of the system (that represents the institutional governance), intermediate (executive) or tactical processes, and operational processes in its inferior part, following a top-down logic, however, with double arrows denoting backflows or bottom-up forces resulting from participatory processes in governance and institutional management.

The products lines demonstrate the flow towards outcomes and *ex-post* impacts and they are a consequence of organizational management processes. Of course, that these blocks contain a series of smaller processes, subprocesses and activities, which will not be detailed here, a measure applicable in the case of an IIAMS operational manual. Always following the basic concepts of the general system theory, the IIAMS Model is subdivided into several phases that compose the system, unfolded according to the level: strategic, tactical and operational, respectively.

Thus, to deepen into the IIAMS in a greater level of detail, it is possible to analyze the sequence of figures from the next pages, where it goes through the details of the interrelationship of each component of the management system with its interactions and products until it reaches the impact level. Note that at each stage of the innovation process the intermediate impact assessment is carried out until the final stages of outputs, outcomes, and *ex-post* impacts are reached. At these points it starts the confrontation between what was planned in terms of *ex-ante* impact targets and what actually occurred in practice, highlighting that measuring outputs and outcomes are important as compatibilization between planning process, although impacts must be the main focus.

All **blocks (from 1 to 4)** in Figure 9, below, are considered as **internal pathways (inside the research organization)**, despite the close relationship from the research organization with the external environment.

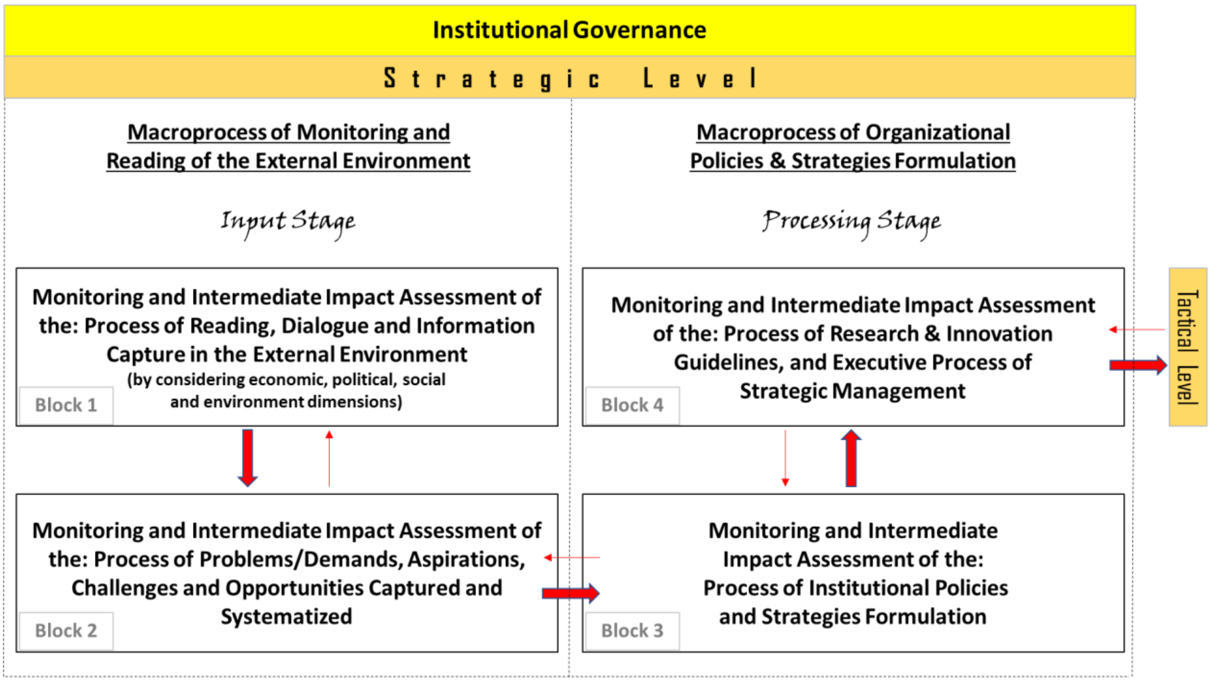


Figure 9. Model of Impact Assessment Management System of Innovation: from a detailed perspective – Phase 1 (Strategic Level)

The Institutional Governance represents the institutional macroprocesses framework, by including the scope while can be observed the interactions of the organization with the external environment and its stakeholders, by considering the commitments to institutions of government, supervision and supreme auditing of public resources. Although institutional governance is arranged horizontally, it must permeate the whole organization through a cross-section and vertical as a way for senior management to monitor and evaluate policies and strategies throughout the institution. Therefore, institutional governance can be verified in a hierarchically superior position to organizational management and it is located at the beginning of the management system, according to indicated in Block 1, below.

Block 1 represents the process responsible to the radar over the external environment. It requires a skilled team to accomplish a set of activities that requires a capacity for dialogue with stakeholders (productive sector, consumers, important players of the market, government representatives, parliament representatives, supervisor institutions, and supreme auditing institution, financers etc), and reading, listening and perceiving the signs of environment in the political, economic, social and read the environmental (social-ecological) needs. It will demand perception, sensitivity, and capacity to read and characterize signals that are not always clear or sometimes are turbulent, diffuse and confusing (in this process it is essential to analyze conflicts of interest).

In articulating with blocks 2, 3 and 4, this process should have a fast-tracking way, that is, structured with continuously channels open to society and the environment, including the productive sector, in order to identify emergence measures or unexpected demands and provide prompt responses to them. Thus, there should be an evaluation of the intermediate impacts of this stage of the process, that must include risks and quality of relationship with stakeholders. It must be operating as an alert thermometer of evaluation, and by making an immediate adjustment of the process when it is necessary. This practice must be applied throughout the pathway of the assessment system.

Block 2 - After the capture of impressions, signs, data and information from Block 1, Block 2 will analyze this material and will produce treated and refined information by systematizing them. Block 2 is a process that should produce a set of information and data that will indicate current scenarios and future trends, problems, opportunities and challenges, by expressing the set of strategic and relevant demands and aspirations of society (including the political and economic dimensions), but even specific and important demands from the productive sector and its supply chains. Different from the economic, political and social dimensions, which are composed of people, the environment is a nonhuman entity and therefore needs people to defend it, protect it and carry out research, formulation, and implementation of policies aimed at its conservation. Thus, it becomes essential to identify what the needs are required for the environment to be resilient. In this sense, the understanding of the environment must be sought not only through dialogue with the leaders' representative of the sector, but also through scientific research.

Block 3 is the process responsible for formulating policies and strategies. It will require building the institutional strategic planning, with the definition of vision, mission, values, objectives, goals and strategic major guidelines. Regarding the intermediate evaluation of impacts, the content of the last paragraph of the previous item is perfectly applicable to this process.

Block 4 represents the process responsible for producing the specific guidelines for Research & Innovation Area, as well as for Administration sectors, by including portfolios definition aiming to reach the stakeholders expectations, demands and aspirations, and environmental needs. The dialogue with the external environment cannot be restricted to the activities of the teams of Block 1. In fact, it is a continuous process along the system, of course, it requires sensitivity and good sense to interact by following criteria, selected groups according to each kind of conversation, as well as the correct timing. It demands a strategic vision, and sometimes it is necessary to separate specific groups and not mix them. So, it is very important and strategic an effective interaction with stakeholders in this stage. Then, the quality of this interaction will be part of the impact evaluation in this stage, as well as the coherence analysis of the external environment demands and expectations, versus the guidelines of the research & innovation established.

By continuing the exposure of the phases of impact assessment management system, Figure 10, below, details the second phase, while demonstrates the tactical level and its components.

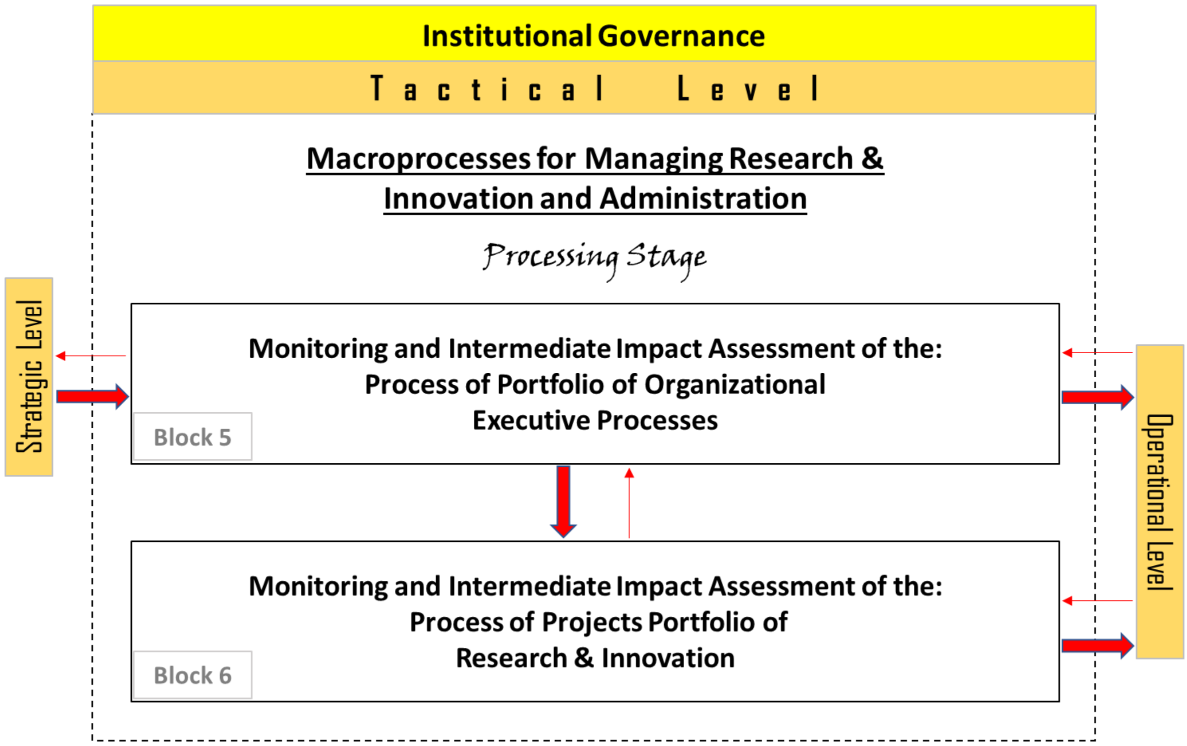


Figure 10. Model of Impact Assessment Management System of Innovation: from a detailed perspective – Phase 2 (Tactical Level)

It demonstrates the basic framework of the research and innovation organization, integrated by a set of processes and project portfolios, as well as the administration area portfolio. Project portfolios are represented by **Block 6**, and they compose the major topics where the projects are linked. It is observable the interaction among all blocks, and especially between the 5 and 6, while it can be identified as a close link of block 6 to the process of research and innovation management. This process is embedded in the set of processes inherent to block 5. This Block requires the intermediary evaluation of impacts concerning the alignment between the demands of the external environment, the strategic plan, and the project portfolio, respectively, without losing sight of the impacts targets, as part of the *ex-ante* impacts established in strategic planning

By continuing the exposure of the phases of the IIAMS, Figure 11, below, details the third phase, while demonstrates the operational level and its components, this time including a processing step, but bringing the output and outcome stages, in the sequential logic inherent to the systemic approach.

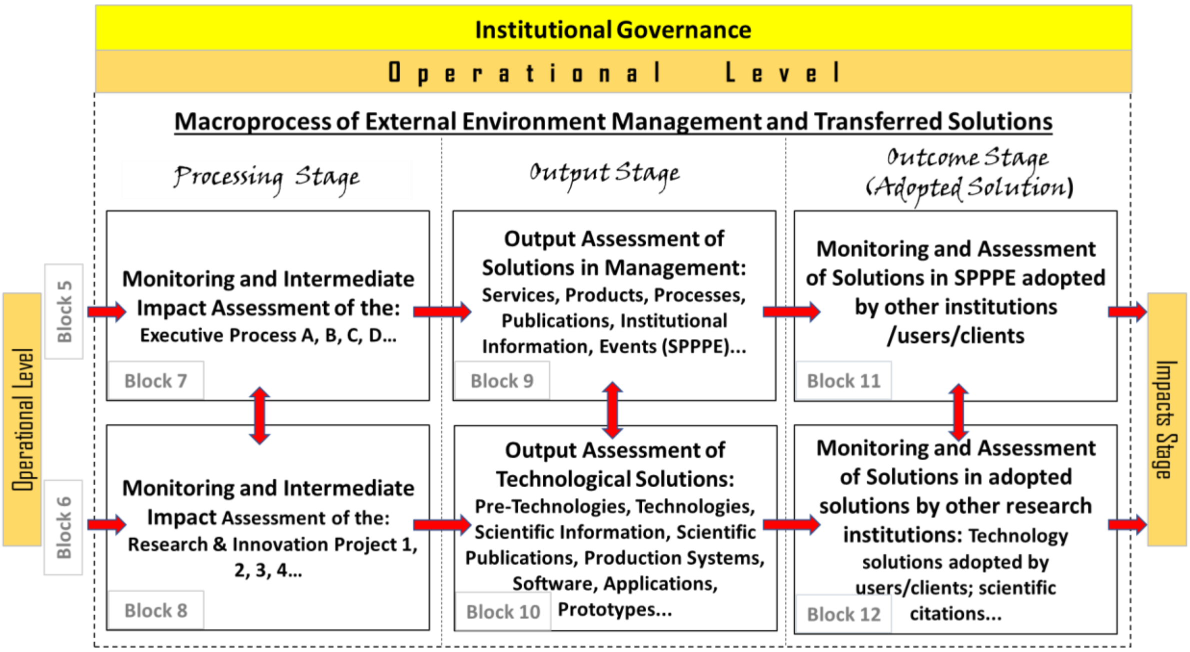


Figure 11. **Model of Impact Assessment Management System of Innovation: from a detailed perspective – Phase 3 (Operational Level)**

Block 7 represents the description of each organizational process, which includes the administrative activities, support, and supplementary activities to become feasible research and innovation (as well as the process of research and innovation management). Processes are a set of activities that, unlike projects, do not have a beginning, middle, and end, that is, they are continuous and essential for organization structuration and maintenance. This Block requires the intermediary evaluation of impacts focusing the alignment between results (intermediate and finals) of each process versus the demands of the external environment, the strategic plan, and the project portfolio, respectively, without losing sight of the impacts targets, as part of the *ex-ante* impacts established in strategic planning.

They include processes directly or indirectly related to the research, such as service contracts, acquisition of machines, equipment, reagents for laboratories, identification and analysis of technology markets in the agricultural sector and correlates, dialogue with stakeholders, innovations satisfaction monitoring and analysis from opinions of customers and users, scientific publications, organization of scientific events among other related processes.

Block 8 is directly derived from block 6 (portfolio projects) and linked to the research and innovation management macroprocess. It represents all of the organization's research and innovation projects, based on each specific topic to which it will be respectively linked.

This Block requires the intermediary evaluation of impacts focusing on the alignment between results (intermediate and finals) of each project versus the demands of the external environment, the strategic plan, and the project portfolio, respectively, without losing sight of the impacts targets, as part of the *ex-ante* impacts established in strategic planning.

The innovation process has started since block 1, but this block (8) represents the beginning of the crucial step of the peer-to-peer operational activity of research and innovation and therefore requires a large exchange of information and knowledge with science and technology partners, market representatives, financers, and also with other actors (internal and external). By ensuring the insertion of constructivist, holistic and transdisciplinarity practices throughout the process, it is essential that t**he solutions should not be the exclusive researcher property, but of the diverse innovation team, which should include not only knowledge coming from scientists, but traditional knowledge, producer's experiences, knowledge from the rural technical assistance workers, among other partners.**

Block 9 refers to information in the form of products, processes, publications, and events, and also services generated by the research organization. Although they represent supplementary activities or support processes to the research, they indirectly make part of the innovation process. Research in generating a technology, for example, if it is a cultivar, will have to produce a minimum of seeds and then multiply it in the market. These seeds to be multiplied can be called products, and it is a process apart from the research, although it has not turned into innovation because the final product has not yet reached the rural producer so that the cultivar can be produced on a large scale.

The same may be true of certain processes or procedures for the management of natural resources or production systems, which may involve some techniques, which, once systematized and ready to be transferred to rural technical assistance, will not involve any more research activity. The outputs related to this Block should be evaluated in terms of the comparison between what was expected from the results and what was achieved, preferably by measuring the percentage of the achievement of the planned goals for the final product.

Block 10 is linked to the research and innovation macroprocess and represents the research's tangible and non-tangible solutions, are the outputs of each project. In this block pre-technologies can be found, which are parts of future technology, and which are usually the result of contractual partnerships or in cooperation with other research organizations. Here are represented the technologies resulting from the researches that, to become innovations, must be acquired and transferred to clients or users. The technologies are tested and validated outputs and can be, for example, agricultural cultivars, embryos, new animal breeds, prototypes, techniques, methods, tools, agricultural implements, software, applications and various ways of expressing scientific information.

The term technological solutions are more in-depth than technologies and represent the set of tested and validated technical knowledge that becomes useful for the productive sector, supply chains, productive arrangements and society, and includes the set of products, processes and services generated. Here are also non-tangible solutions, such as information expressed in various ways, such as a simple technical orientation, based on scientific research and that guaranteeing more productivity gains, cost-of-production savings, better production system management practices or practices that promote environmental sustainability improvements, for instance, by reducing carbon emissions.

Blocks 11 and 12 are inserted in the outcomes step, which are the solutions, services or products transferred to customers and users. Blocks 11 and 12 are closely related to solutions generated in the field of scientific innovation, but also the scope of political, managerial and institutional solutions.

Block 11 is included institutional publication (on paper or in electronic format) or accomplished events on institutional policies and strategies, integration into policy public related to the agricultural sector, sustainability, food, health and nutrition or related topics. In this block are included all type of services produced by the organization to the external environment and related to its institutional mission and impact targets. Can be output directed to public institutions, rural technical assistance organizations, representatives of the productive sector, other research organizations, private companies, leadership of supply chains, industries, partners, parliament, supreme auditing institutions, universities, important players in the agribusiness, multilateral organisms, strategic foreign people and institutions, and others.

Block 12 represents the set of pre-technologies transferred by the research organization to other organizations or researchers to continue the production of a new technology to be launched. It can also be articles accepted or published in scientific journals in issues related to the pre-technologies or advances in knowledge, and also consists of the set of technological solutions transferred to other organizations, for an institution or company of rural technical assistance, for producers or agroindustries, and all type of clients and solution users, according to each case. It can also be articles accepted or published in scientific journal on issues related to the technology solutions, and other scientific publications (in paper or electronic format), accomplished events (field days, meeting, seminaries, workshops and lectures) as part of technologies or knowledge transfer; tv, radio, social media programs participation or presented video related to some technology or knowledge transfer.

Figure 12, below, advances in detailing the IIAMS model, still within the operational level, but addressing the *ex-post* impacts, which represent the heart of the system.

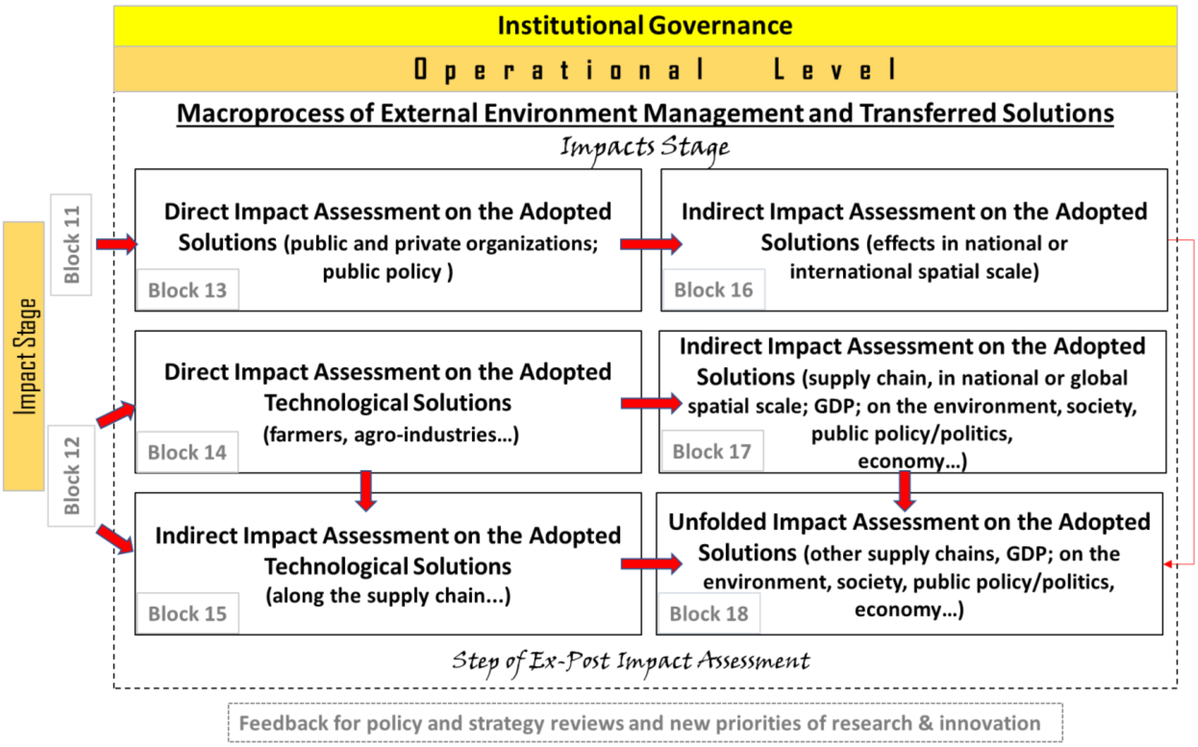


Figure 12. Model of Impact Assessment Management System of Innovation: from a detailed perspective – Phase 3 (Operational Level- Impacts Stage)

From blocks 13 to 18 are the external stages of the *ex-post* impact pathway, which will later have some examples with detailing the routes. The previous blocks, from 1 to 10, represent the internal steps of the impact pathways (within the internal domains of the research organization). From the block 11 to 12 represents external stages, although they do not constitute *ex-post* impacts, but outcomes yet (in these zones can be verified the important and delicate role of solutions transfer which will link outputs and impacts). It is important to note that the impacts generate the opposite flows or reactions towards the organization that generated the outcomes and outputs and can arouse negative or positive influences to the whole institution, it is like a reflex of a rebound. By way of illustration, using a physical example, it is enough to imagine when throwing a stone over the water of a lake, the wavelets will be directed in all directions, even towards the author of the throw of the loss.

Block 13 has a direct relationship with previous Block 11 and represents the set of adopted solutions originated from an area not directed related to the scientific activities. In this case impacts will be evaluated focusing partner organizations or clients that received and multiplied knowledge, institutional information, processes (some organizational technology or published public policy, for instance), products (acquired institutional publications or electronically accessed, for example).

Block 14 is closely related to the output from Block 12, that is, direct impacts on the property (farm or agro-industry, for example) where the technological solution generated by the research organization was adopted. These impacts usually have a pathway that transcends faster(short term) the time dimension than indirect impacts, although they may extend in the medium and long term, with possible perennial effects depending on each case. The impact is directly on the producer's economy, on his social context (improvement of his quality of life and his family), as well as the direct impact on the environment of the farm or productive property. All these impacts must be monitored and measured.

Block 15 means indirect impacts resulting from the adoption of direct impacts in the agricultural or agro-industrial sector. For example, farmers have adopted certain technological solutions and the result of these solutions (agricultural production) is sold to agro-industries processing the primary product. Thus, it continues as an indirect impact when the industries or agroindustries and other members of the respective supply chain are impacted by the original solution, which will be undergone by an impact assessment process. Other indirect impact examples are: a prototype adopted by an industry which generates a production system that, in the supply chain sequence, engages a logistics and distribution system of trade companies; or a pre-technology that was later part of a complete technology which later generated some impacts. Thereby, indirect impacts are the effects of a technological solution on supply chains linked originally to the primary product, even if new stages along the supply chain are related to the original product. Also effects for the gross domestic product (GDP), with respective impact on the municipality- or state- or national income.

The three blocks, **16, 17 and 18** are illustrative examples in the column of indirect and unfolded impacts and refer to effects at a further level from the first impacts or direct impacts, therefore, their consequences tend to be located on a medium- and long-term time scale. As in other impact cases, they must also consider the consequence of solutions in the environment, society, economy and the political context.

Block 16 demonstrates a sequence of impacts along the impact pathway, which generate effects to the municipality and state, being able to migrate to other states, by aggregating value throughout its course in the country and even in other countries. These are impacts originally concerned to the activities not directly related to scientific production, but institutional (public policies and organizational technologies, for instance).

Block 17 exemplifies cases in which indirect impacts occur along supply chains linked to the product originally supported by a specific technological solution adopted in farm, industry, trade or information area related to the agricultural sector or agribusiness.

Block 18 illustrates the unfolded impacts, which are derived from indirect impacts. As mentioned earlier, these impacts are generated in different supply chains or production processes different from the one related to the original product that was made possible by the adoption of a particular technological solution. One solution generates direct impacts, which in turn can generate indirect impacts and consequently chain effects, multiplying in other supply chains or other business fronts, impacting the economy, society, politics and the environment of these new businesses. All of them must be evaluated.

4.7. Spatial Scale-Based Innovation Impact Assessment Strategy and Sustainability Indicators

As an unfolding of the IIAMS and detailing the understanding of its operation, this item seeks to deepen into the dimensions of space, an essential factor for the operation of the system model. **We did not contemplate the timescale in this planning base due to the complexity of the time factor in the impact analysis, because there is the question of the time delay so that several of the impacts are manifested, generating dyssynchrony between the time-space** factors.

When dealing with a very large universe of variables (involving several plant species, interaction with livestock, besides prototypes, software and other technologies of non-biological origin), the temporal unpredictability becomes complex. Biological and environmental factors provide for a very wide spectrum of variables, and become even larger, given biological reactions caused by climatic factors, for example. Under natural conditions, the tendency is that as a product moves away from its producing center (space dimension), it would take longer to reach its spatial end, generating later impacts compared to local impacts. But this hypothesis is not true. Nowadays, the time dimension assumes a different dynamic when it comes to faster ground transportation or air transportation, which accelerates the entry of products into various national and global markets, and can generate faster impacts in a global market than in the national market, or same place, especially in the economic aspect. And in the environmental case, the impact would be almost simultaneous in the case of carbon emissions.

By focusing on the impact assessment, the IIAMS adopts as an **intervention strategy the spatial scale as a planning base**. Thus, starting from the **local**, passing through the **state or region and national**, up to **the international or global level.** The inter-scale movement occurs when various **geographic spaces are crossed through elements that integrate natural processes**, for example: water flow and streams, atmospheric phenomena, such as the air temperature, the atmospheric pressure, the wind currents, the air humidity, the evaporation, the clouds and the precipitations, in addition to plant transpiration, geological processes, pollination, and migration of animals. And when **geographic spaces accrossed through the supply chains or markets**. Figure 13, below, shows the five spatial scales and their respective indicators categories.

World

Country

Region / State

Around the farm and the municipality

Local – Inside the Farm

- Soil (Quality & Conservation) [E]
- Water (Sustainable Use & Quality) [E]
- Production System Diversification [E]; Waste Management [E]
- Landscape (compliance with law) [E]
- Atmosphere: carbon balance [E]

- Quality of life [S];
  Education and Health, Nutrition, Food Safety (HNF) [S]
- Cohesion & Social Inclusion (C&SI) [S]
- Job Creation [S]
- Respect to the Local Culture [S]

- Local impact of national, state or municipal policies [P]
- Level of alignment along the impact pathways (*ex-ante* impact targets and *ex-post* impacts achieved) [P]

- Producer Profitability [Ec]; Access to Production Assets [Ec]
- Post Harvest/Production Losses [Ec]

Around the farm and the municipality:

- Level of hydrographic basin conservation [E]

- HNF of state population [S]
- C&IS [S]
- Respect to the regional culture [S]
- Job creation [S]

- Supply chains creation or strengthening [Ec]
- Impact on the regional/state's Gross Domestic Product (GDP) [Ec]

Region / State:

- Level of micro-hydrographic basin conservation [E]
- Landscape [E]
- Waste management [E]

- Job creation [S]
- Respect to the local-regional culture [S]
- C&IS [S]
- HNF [S]

- Creation or strengthening of local productive arrangements [Ec]
- Creation or strengthening of supply chains [Ec]

Country:

- Research Organization (RO) contribution to the national carbon balance [E]

- Consumers satisfaction level from innovations; HNF ; C&IS and Job creation [S]

- National Policy Compliance Level [P]

- Supply chains expansion or strengthening [Ec]
- RO contribution to the country's GDP and Internal Rate of Retourn (IRR) [Ec]

World:

- RO contribution to the global carbon balance [E]

- Satisfaction level of international consumers in relation to imported product resulting from RO innovations [S]

- RO contribution to the global policy of achieving UN sustainable development goals [P]

- RO influence on producers, firms or supply chains in access to international markets [Ec]

E=Environmental Dimension; S=Social; P=Policy/Political; Ec=Economic

Figure 13. Impacts Through the Five Spatial Scale Perspective

Figure 13, above, displays the indicators categories of impacts at each level of spatial scale, with the first degree of a direct impact on the property or the local level (within the farm or industry that adopted the technological solution generated by the research organization) and from this local space to larger spatial scales. From this center of impacts there is the displacement towards the borders, that is, the scale is expanding, passing through the neighborhood of the local property and encompassing the entire area of the municipality where it is located. Then the impacts reach the state unit of the federation, then the geopolitical region and so reaches the national level. As the product generated by the property enters supply chains that reach other country markets, the impact is moving in the international and worldwide scope.

The spatial scale therefore has a direct relationship with the degree of data and information added, going from the most detailed to the most summarized, respectively, from Zone 1 to 5, and this logic will be reflected in the reports that will consolidate such information. Zone 1 of the spatial dimension represents the space-local, within the property. Zone 2 is the municipal space, where the property is located. Zone 3 is the state or geopolitical region where the municipality is located. Zone 4 is the country space where the state or region is located. Zone 5 is the international space or global area. The model sets a cross-cut of the indicators through the various spatial scales, being more detailed at the operational level, within the property. At the municipality level, there is more concentrated information. Thus, with more aggregates at the state and national level, respectively, and finally being more summarized at the international or global level, by searching to narrow down into few and essential indicators.

When analyzing the sustainability dimension (economic, political, social and environmental), as well as their respective components, attributes, and indicators, it can be seen a larger set of items in the environmental and social dimensions for local scale, and fewer items on political and economic issues. It is because risks to the environment may generate irreversible local impacts or unfolding sequential process of negative effects on society and the economy, considering the principle of transversality, according to the conceptual analysis of Figure 8 (page 1309).

On the other hand, it is necessary to emphasize the high degree depth, and impact expressed in political and economic components descriptions. Furthermore, when analyzing state, national and global scales these indicators are leveled. And yet, when calculating the sustainability balance of a technology solution, it is necessary to always apply the weighted average as a way of equalizing these differences.

5. The Key Ideas Part III

Part III was based on four chapters:

- the definition of the proto-model as the initial reference of an innovation impact assessment model, which should serve as the basis for the analysis of the experiences of four research organizations;
- inspired in the proto-model, to make an analysis of the experiences of four research organizations regarding their innovation impact assessment models;
- the benchmarking, that is, the identification of important points in the four experiences studied, promoting improvements in these points; and
- the construction of an improved model for assessing the impact of innovation, with special attention for agricultural research organizations.

The improved final model was the result of the convergence of theoretical knowledge (based on a literature review) and experiences of four research organizations. Supported by the general theory of systems, this model encompasses the eight variables that have arisen since the design of the proto-model, as well as a set of details that represent the deployment of IIAMS with its basic definitions, its components and its way of operationalization.

The IIAMS brings an emphasis on aspects of sustainability as crucial for research organizations and production processes to meet the UN's sustainable development goals. The new model also emphasizes behavioral aspects (such as holistic, constructivist and transdisciplinary vision, as well as insertion of agile leadership issues), as a differential to effectively drive of innovation impact assessment processes (and which are recommended to be inserted through each step of the innovation process).

It is advisable to look at Annex 4 where it will be possible to verify in more detail information about the structure and operation of the IIAMS, including some by-products that emerged during the discussion and conclusion of the Model (Annex 4 - Further Operational Information of IIAMS).

General Conclusion and Suggestions for Future Researches

The main result expected from the effective operation of the innovation's impact assessment management system is to support organizational governance and management, by positively influencing towards continuous improvement of innovation policies and strategies of research projects. It will be operated through the feedbacks of the system that should help the organization achieve growing sustainability in its solution production so that **agricultural systems and its supply chain can be increasingly sustainable, thus meeting the UN's sustainable development goals, especially meeting goals 2 and 12**.

The world needs to reduce social inequalities, eliminate hunger and sustainably expand food production. Agricultural research organizations are key players in this scenario and need to be in direct alignment with those needs, already validated by the United Nations.

Most of the agricultural research organizations around the world are already seeking to internalize the sustainable development goals of the UN. Thus, evaluating the impact in the economic, political, social and environmental field of its research and therefore of its innovations, becomes fundamental in the pathway of the growing search for the sustainability of the countries and the planet.

It is hoped that agricultural research organizations can increasingly generate sustainable technological solutions to promote increasingly sustainable agriculture.

From this perspective, proposing the improvement of the impact assessment systems was an important product of this thesis, as a way of contributing to the efforts towards sustainable development, as well as to support the decision-making processes of research institutions, especially from the agricultural sector. IIAMS intend to support the priorities redefinition of research innovation, in response to the expectations of their stakeholders.

It is expected a balance between the desires and expectations of society (including social, political and economic dimensions) and the needs that the environment requires for its resilience. The accounting balance sheet should be the protagonist of future demands of supreme audit institutions by requiring innovation impact assessment as part of this balance demanded by research organizations.

Organizations implement policies, plans, programs, projects and activities, as well as generate products and services. Then, organizations generate impacts and conflicts of interest. All these conflicts and impacts can be well governed and managed if organizations create consistent systems of impact assessment.

The complexity of the theme and the interweaving of environmental, social, political and economic dimensions require an essentially holistic, constructivist and transdisciplinary vision, demanding more extensive creation for integrative methodologies on impact assessment under sustainability perspective and using cross-cut approach for analysis, as well as agile leadership approach in its managerial and governance processes. Few methodologies and experiences have shown a balance between all these dimensions and, in general, are adopting methods or practices with bias, emphasizing one aspect over another.

In addition, impact assessment approaches tend to focus exclusively on analyzing *ex-ante* impacts or *ex- post* impacts. Currently, research organizations emphasize one or two components only among the environmental, social, political or economic dimensions. The IIAMS is based on an approach that considers the balance between all these dimensions. Thus, this new approach seeks to revise the concept of impact assessment from a comprehensive perspective, including the *ex-ante* and *ex-post* phases as part of a single evaluation system, which should be addressed by integrated management. Reports generated by IIAMS will be useful for strategic, tactical and operational decision-making processes, providing subsidies to adjust policies, plans, programs, processes, projects, products and services, aiming at a more sustainable production.

We have adopted a methodological strategy called “method of development strategy” (Contandriopoulos et al., 1994, p.41) which aims to improve some specific technology, in this case, a model of innovation's impact assessment system.

In this way, the thesis was based on a review of the literature and, in this review, proposed a proto-model as a basic reference for the construction of an improved model of impact assessment of innovation, with special attention to research organizations in the agricultural sector. After the proto-model, we sought to analyze the experience of four research organizations (Cirad, Inra, Embrapa and CSIRO), considered as important institutions references in the world and in their continents, as summarized following.

Although several aspects such as structural, behavioral, supply chain and other issues were analyzed, eight factors were adopted as the main reference in the study: connection of the impact assessment system with institutional policies and strategies; the existence of framework for impact assessment in the research organization (as organizational unit, resources and staff); connection between the impact assessment system with the innovation process; the process of innovation and impact assessment process under the constructivism, holism and transdisciplinarity concepts; sustainability approach by a cross-cut perspective; and the impact assessment system considered from process analysis by viewing the impact pathway perspective and e*x-ante*/*ex-post* analysis.

In general, each institution has shown one aspect or another in a more structured way and with better performance than the other. For example: CSIRO has clearly connection between its institutional policies and strategies with its impact assessment system. Cirad and Inra have non-fixed framework for their impact assessment process, which is driven by specific projects; while Embrapa and CSIRO have fixed framework for attending impact assessment process. Although the four organizations cite innovation as a key player in the science and technology production process, they do not have a systemic and coupled connection between the innovation process and impact assessment.

With the exception of Cirad, which takes a broad view of constructivism as part of building the innovation process and evaluating the impact of innovation, other institutions make no inference about this approach, and none of them makes clear the incorporation of holistic and transdisciplinary vision during their process of impact assessment. Cirad and Inra make important reference to the UN's sustainable development goals, different from other institutions. On the other hand, Embrapa has a much more assertive approach towards a sustainable view, which was observed in its impact assessment model. CSIRO and Embrapa cite the impact pathway in their methodologies, however, about this perspective, Cirad and Inra are more emphatic in their approaches. Cirad has been working on *ex-ante* and *ex-post* evaluations, although it does not address them in a systemic and integrated way. The other institutions approach only *ex-post* evaluations.

Table 4, below, summarizes the thesis demonstrating its central goals, the respective achieved results, and expected impacts:

Table 4. Summary of Comparative Analysis between this Thesis goal and its Results

Goals	Results	Impacts of the Results (Benefits)
Synthesis of Impact Assessment Approaches, and Impact Analysis Methodologies of Four Research Organizations – Cirad, Inra, Embrapa and CSIRO, towards Benchmarking.	▪ The four research institutions studied have positive aspects regarding a good connection between its institutional policies and strategies and the research impact assessment process. About the framework of impact assessment, only Embrapa and CSIRO have a permanent structure for research impact monitoring and evaluation. Cirad and Inra work through specific projects. The innovation process is considered by the four institutions as a base to the impact evaluation process. However, Cirad's, although it does not represent an exact coupling, its approach is the closest to the idea of overlapping the impact assessment model with the innovation process, based on a systemic view. None of the institutions systematically addresses behavioral aspects in their completeness (holism, constructivism, transdisciplinarity, and approaches in management), as recommended by IIAMS. Despite of that, Cirad takes a consistent approach to constructivism. Only Cirad and Inra make citations in their approaches about the UN sustainable development goals, as well as the importance of constructing research impact assessment models. However, Embrapa's model is the closest to a cross-cut approach to sustainability, although that can be improved. The four institutions deal with the impact pathway as key points in the evaluation process, but Cirad and Inra are the ones that apply this issue more in terms of methodological steps, especially the Cirad model. ▪ The IIAMS model absorbs the following strengths from the experiences of the four institutions: the focus on the impact pathway; the coupling between the innovation process and the impact assessment process; the link between institutional policies & strategies and the impact assessment process; the insertion of the concepts of constructivism as an essential behavioral aspect for the success of the model application; a permanent organizational structure for coordinating the research impact assessment process;	Old and recent theories and approaches were important during the literature review as input to the new model construction, as well as positive points were identified of four research organizations studied. It was highlighted the strengths identified as input for benchmarking, which were inserted in the new design of the impact assessment model of innovation, as well as in the verification of gaps or improvement points that were also incorporated into the new model.

	integrated vision of sustainability.	
Conceptual Model of the Impact Assessment Management System of Innovation	▪ The model was constructed based on the positive aspects identified in the four research institutions experiences. These experiences have been added to the positive theoretical aspects identified in the literature as: integrated and interconnected vision of the managerial process of impact assessment system, by considering *ex-ante* and *ex-post* assessment stages; it was inserted the holism, transdisciplinarity, and management approach (agile leadership) in addition to constructivism as the behavioral approach; the insertion of political and policy theories as a linked approach between them as important aspects to the model success; a cross-cut view of sustainability was inserted in the model by considering a scale rating among the environmental, social, political and economic dimensions, in descending order, respectively.	An improved model which has inserted important behavioral approaches as essential practices for the success of its process of implementation, resulted from positive practices of research organization studied, by benchmarking approach. The IIAMS will be important governance and managerial tool for decision-making in (re) designing and (re) setting priorities of policies, plans, research projects and continuous improvement of innovation for research organizations. It is expected that the new model can help research organizations (especially from the agricultural sector) to meet the UN sustainable development goals, especially goal 2.

The model developed here complements and helps the current models, including the Embrapa's approach in the aspects related to the management system for monitoring and impacts evaluating by a unique and integrated managerial view. Another contribution of this thesis refers to the behavioral approach, with an integrated view of concepts of holism, constructivism, transdisciplinarity and agile management, which, in general, are superficial or fragile or even nonexistent in most existing research impact assessment systems.

This thesis also contributes with a cross-cut view through a perspective of sustainability that allows a classification of the impact indices taking into account that the environmental dimension represents the ambiance greater than the others, since it is in it that are immersed the social, political and economic, respectively. It is worth mentioning that the political dimension was added to the evaluation process considering two approaches: one related to the public policy structuring, its elaboration, implementing and assessment of its impacts, another one related to the impacts arising from the political processes (governance). For instance, the way of driving an innovation strategy (a poorly managed policy from the management point of view may condemn a public policy or innovation strategy to failure).

The Brazilian policy of low carbon emission of agriculture - ABC Plan (Mapa, 2018) has provided improvements in the production processes of grains and meat production, especially with the insertion of the planted forest component, but this public policy can be still more effective. The improvement resulted from the IIAMS can generate positive impacts to the ABC Plan, by redefining its framework, strategies and operational priorities. This improvement can help Brazil and the process of sustainable rural development about the reduction of carbon emissions in agriculture and the search for solutions that improve even more the income and quality of life of producers and their families. While obtaining more efficient monitoring process of *ex-post* impacts along the supply chain, including their lag effects, better products for consumers and better and more positive answers for funders and stakeholders will be met, as well as wider environmental responsibility will be reached.

In order to apply IIAMS, it is essential to prepare an operational guide capable of translating each step to the real world, with methodological details, including specifying the executive management framework of the whole process.

In terms of advances in the model improvement, it is suggested a field work that involves other biomes and other agricultural dynamics, on the one hand aiming the validation of this model and, on the other hand, the refinement of some research data, such as the number of actors to be involved along the supply chain and model application costs.

The next step will be my reintegration to Embrapa and, I hope to be able in this process, to implant the IIAMS in this institution in order to promote an improvement in the process of assessment of the research & innovation impact currently underway in the organization. To become this Model functional, it will be necessary an operational guide as next work to be developed.

References

Ahmed, P.K. and Rafiq, M. (1998). Integrated benchmarking: a holistic examination of select techniques for benchmarking analysis. Benchmarking for Quality Management and Technology, Vol. 5 No. 3, pp. 225-42.

Alston, J. (2010). "The Benefits from Agricultural Research and Development, Innovation, and Productivity Growth," OECD Food, Agriculture and Fisheries Papers, No. 31, OECD Publishing, Paris. Available at: http://dx.doi.org/10.1787/5km91nfsnkwg-en, accessed 03/20/2018.

Alston, J.M.; Norton, G.W; Pardy, P.G. (1995). Science Under Scarcity: Principles and Practices for Agricultural Research Evaluation and Priority Setting. Cornell University Press and ISNAR, Ithaca.

Ansell, Chris and Gash, Alison. (2007). Published by Oxford University Press on behalf of the Journal of Public Administration Research and Theory, doi:10.1093/jopart/mum032.

Asif, M.; Searcy, C.; Zutshi, A. & Ahmad, N. (2011). An integrated management systems approach to corporate sustainability. European Business Review, 23(4): 353 – 367.

Australian Government – AG. (2010). Australia and Food Security in a Changing World Available at: https://www.chiefscientist.gov.au/wp-content/uploads/FoodSecurity_web.pdf.

Avila, A.F.D.; Rodrigues, G. S.; Vedovoto, G. L. (2008). Avaliação dos impactos de tecnologias geradas pela Embrapa: metodologia de referência. Embrapa Informacao Tecnologica. ISBN 978-85-7383-420-8. Available at : https://www.embrapa.br/busca-de-publicacoes/-/publicacao/15196/avaliacao-dos-impactos-de-tecnologias-geradas-pela-embrapa-metodologia-de-referencia, accessed 02/08/2018.

Bakker, Arnold B.; Schaufeli, Wilmar B.; Demerouti, Evangelia; and Euwema, Martin C. (2005). An organisational and social psychological perspective on burnout and work engagement. Utrecht University, The Netherlands. Available at: https://www.isonderhouden.nl/doc/pdf/arnoldbakker/articles/articles_arnold_bakker_140.pdf.

Bantilan, Cynthia; Templeton, Debbie and Craswell, Eric. (2014). Concepts and Tools for Agricultural Research Evaluation and Impact Assessment - Report on Master Class on Impact Assessment International. Edited by Crops Research Institute for the Semi-Arid Tropics, Patancheru, A.P., India 18 – 27 March 2009. https://www.crawfordfund.org/wp-content/uploads/2014/03/Impact_assesment_Masterclass.pdf.

Barbieri, Jose Carlos; Vasconcelos, Isabella Freitas Gouveia; Andreassi, Tales; Vasconcelos, Flávio Carvalho. (2010). Innovation and Sustainability: new models and propositions. RAE Sao Paulo, Volume 50, N. 2, pp. 146-154. ISSN 0034-7590. Available at: http://www.scielo.br/pdf/rae/v50n2/02.

Barret, D. ; Blundo Canto, G.; Faure, G.; Hainzelin, E.; Monier, C. ; Triomphe, B. (2018). Impress Ex-Ante : Une proposition de démarche pour construire ex ante les chemins de l'impact. CIRAD. Available at : https://agritrop.cirad.fr/587110/1/ID587110.pdf.

Barret, D.; Clavel, D.; Dabat, M-H. ; Faure, G. ; Mathé, S. ; Temple, L. ; Toillier, A. ; Triomphe, B. (2015). Centre de coopération internationale en recherche agronomique pour le développement – Cirad : Available at : http://impress-impact-recherche.cirad.fr/.

Barros de Mendonca, Savio & Laques, Anne-Elisabeth. (2017). Sustainability Impact Assessment – An Overview with a Holistic and Transdisciplinary Perspective towards Agricultural Research. Edited by Environmental Management and Sustainable Development Journal – Macrothink Institute. ISSN 2164-7682 2017, Vol. 6, No. 2. Available at: http://www.macrothink.org/journal/index.php/emsd/article/view/11333/9169.

Bartholomew, K., Henderson, A.J.Z. and Márcia, J.E. (2000). Coding semistructured interviews in social psychology research. Em H.T. Reis & C.M. Judd (orgs.), Handbook of research methods in social and personality psychology (pp.286-312). UK: Cambridge University Press.

Becker, Henk A. (2001). Social impact assessment. European Journal of Operational Research 128 311-321, www.elsevier.com/located/dsw.

Becker, Henk A. and Vanclay, Frank. (2003).The International Handbook of Social Impact Assessment: conceptual and methodological advances. Edward Elgar Publishing Limited, Cheltenham, UK.

Bertalanffy, L. von. (1968). General System Theory: Foundations, Development, Applications. New York: George Braziller.

Birkland, Thomas A. (2016). An Introduction to the Policy Process – theories, concepts, and models of policy public making. Routledge, fourth edition, Taylor & Francis Group, New York. ISBN 9781317509806 (ebook).

Bradberry, Travis. (2018). 11 Signs That You Lack Emotional Intelligence. Tallentsmart, Newsletter Articles. Available at: http://www.talentsmart.com/articles/11-Signs-That-You-Lack-Emotional-Intelligence-2147446699-p-1.html.

Brian, Belcher and Palenberg, Markus. (2018). Outcomes and Impacts of Development Interventions:Toward Conceptual Clarity. American Journal of Evaluation 1-18. Sagepub.com/journalsPermissions.nav, DOI: 10.1177/1098214018765698, journals.sagepub.com/home/aje.

Brooks, J., & Brooks, M. (1993). The case for the constructivist classrooms, p. vii. Alexandria, Va: ASCD.

Buckley, W. (1976) A sociologia e a moderna teoria dos sistemas. Trad. O. Cajado), 2ed, São Paulo, Cultrix, pp 9-68.

Calbo, Adonai G. and Pusinhol, Carlos Cesar. (2017). Pre-MK: Tecnologias, seus gêneros e seus trunfos. Embrapa Instrumentacao, 1ª edição. Available at: www.embrapa.br/fale-conosco/sac.

Caon, J. L. (1998). Da existência analfabética à existência analfabetizada. Revista do GEEMPA, 6, 37-70. Available at: http://www.scielo.br/scielo.php?script=sci_nlinks&ref=000152&pid=S1413-81232009000800015000013&lng=pt, accessed on 03/11/2018.

Carmeli, Abraham; Meitar Ravit; Weisberg, Jacob. (2006). "Self-leadership skills and innovative behavior at work", International Journal of Manpower, Vol. 27 Issue: 1, pp.75-90, https://doi.org/10.1108/01437720610652853.

Casa Civil – Presidencia da Republica / PR. (2012). Lei nº 12.651, de 25 de maio de 2012 – Dispoe sobre a protecao da vegetação nativa. Available at: www.planalto.gov.br/CCIVIL_03/_Ato2011-2014/Lei/L12651.htm.

Cato, Molly Scott. (2009). *Green Economics*. London: Earthscan, pp. 36–37. ISBN 978-1-84407-571-3.

Centre de cooperation internationale en recherche agronomique pour le developpement – Cirad. (2017). Vision stratégique et ambitions du Cirad 2018-2028. Available at: www.cirad.fr/.../Vision-strategique2018-2028.pdf, accessed 03/13/2018.

Centre de cooperation internationale en recherche agronomique pour le developpement – Cirad. (2015). The ImpresS ex post method: a co construction process with our partners. Available at: https://impress-impact-recherche.cirad.fr/ex-post/the-impress-ex-post-method.

Centre de coopération internationale en recherche agronomique pour le developpement – Cirad. (2016). Qui sommes-nous ? Notre strategie. Available at: https://www.cirad.fr/qui-sommes-nous/notre-strategie, accessed 02/18/2018.

CGIAR. (2017). Homepage: www.cgiar.org.

Chahal, Mindi. (2016). The new era of leadership: the management styles unlocking unique ways of thinking. Marketing Week. Available at: https://www.marketingweek.com/2016/04/29/the-new-era-of-leadership/

Chesbrough, H.W.; West, J.and Vanhaverbeke, W.(2006). Open Innovation: Researching a New Paradigm. Oxford: Oxford University Press.

Christensen, Clayton M.; Raynor, Michael E. and McDonald, Rory. (2015). What is disruptive innovation? Harvard Business Review, December, 2015. https://hbr.org/2015/12/what-is-disruptive-innovation.

Cohen, E., & Lloyd, S. (2014). Disciplinary evolution and the rise of the transdiscipline. Informing Science: the International Journal of an Emerging Transdiscipline, 17,189-215. Retrieved from http://www.inform.nu/Articles/Vol17/ISJv17p189-215Cohen0702.pdf.

Colinet L., Joly P-B., Gaunand A., Matt M., Larédo P., Lemarié S. (2014). ASIRPA – Analyse des Impacts de la Recherche Publique Agronomique. Rapport final. Rapport préparé pour l'Inra. Paris, France.

Commonwealth Scientific and Industrial Research Organisation – CSIRO. (2015). Impact Evaluation Guide. Strategy, Marketing Vision and Innovation. Available at: www.csiro.au.

Commonwealth Scientific and Industrial Research Organisation – CSIRO. (2017). The Value of CSIRO. An Estimate of the Impact and Value of CSIRO's Portfolio of Activities, conducted by Acil Allen Consulting. Available at: www.csiro.au.

Commonwealth Scientific and Industrial Research Organisation – CSIRO. (2018). Corporate Plan 2018. Available at: www.csiro.au.

Contandriopoulos, A. P.; Champagne, F.; Potvin, L.; Denis, J.-L. & Boyle, P. (1994). Saber preparar uma pesquisa. São Paulo: Hucitec-Abrasco.

Convention on Biological Diversity - CDB. (2006). The voluntary guidelines for biodiversity-inclusive impact assessment, adopted through decision VIII/28 : http://www.biodiv.org/programmes/cross-cutting/impact/search.aspx.

Copenhagen Convention Bureau – CCB. (2014). 8 reasons why sustainability drives innovation. Official site: http://www.copenhagencvb.com/copenhagen/8-reasons-why-sustainability-drives-innovation.

Craig, Deegan. (2002). The legitimizing effect of social and environmental disclosures – a theoretical foundation. Accounting, Auditing & Accountability Journal, Vol. 15, n°3, PP. 282-311.

Christensen, Clayton M.; Raynor, Michael and McDonald, Rory. (2015). What Is Disruptive Innovation? Twenty years after the introduction of the theory, we revisit what it does—and doesn't—explain. Harvard Business Review. Available at : http://pedrotrillo.com/wp-content/uploads/2016/01/Whatisdisruptiveinnovation.pdf.

Culture and Leadership Workstream - CLW. (2017). Culture and Leadership: The Nine Principles of Agile Leadership. Available at: https://www.agilebusiness.org/resources/white-papers/culture-and-leadership-the-nine-principles-of-agile-leadership.

Dalziel, M. & Parjanen, S. (2012). Measuring the Impact of Innovation Intermediaries: a case study of Tekes. In: Melkas H., Harmaakorpi, V. (eds). Practice Based Innovation: Insights, Applications and Policy Implications, pp 117-132. Springer, Berlin, Heildelberg, http://doi.org/10.1007/978-3-642-21723-4_7.

Diez, Maria Angeles. (2001). The Evaluation of Regional Innovation and Cluster Policies: Towards a Participatory Approach. European Planning Studies Journal. Volume 9 Issue 7. https://doi.org/10.1080/09654310120079832.

Donahue, John. (2004). On Collaborative Governance. Corporate Social Responsibility Initiative Working Paper No 2. Cambridge, MA: John F. Kennedy School of Government, Harvard University.

Douthwaite, Boru; Kubyb, Thomas; Fliertc, Elske van de and Schulzd, Steffen. (2003). Impact pathway evaluation: an approach for achieving and attributing impact in complex systems. Agricultural Systems 78 (2003) 243–265, doi:10.1016/S0308-521X(03)00128-8. Available: http://boru.pbworks.com/f/ag_syst_IPE.pdf, accessed 01/23/2018.

Empresa Brasileira de Pesquisa Agropecuaria – Embrapa. (2017) - Gestão Estratégica - Embrapa gera impactos efetivos para a sociedade brasileira. Site https://www.embrapa.br/group/intranet/busca-de-noticias/-/noticia/21885057/embrapa-gera-impactos-efetivos-para-a-sociedade-brasileira.

Empresa Brasileira de Pesquisa Agropecuária – Embrapa. (2018).Organization's main site, available at: www.embrapa.br, accessed 03/18/2018.

European Commission - EC. (2017). Glossary. Available at: http://bit.ly/2060g24, accessed 04/15/2018.

European Commission – EC. (2019). ICT Impact Assessment Guidelines: practical tools and guidelines for assessing ICT implications. Available at: https://ec.europa.eu/isa2/sites/isa/files/ict_impact_assessment_guidelines.pdf.

European Environmental Agency - EEA (2001). Participatory Integrated Assessment methods: an assessment of their usefulness for the European Environmental Agency. Technical Report 64, Copenhagen. Available at: http://www.pedz.uni-mannheim.de/daten/edz-bn/eua/01/tech64.pdf, accessed 02/27/2018.

Fachinelli, Ana Cristina; D'arisbo, Anelise; Maciel, Erick de Melo. (2014). A Importancia da Inovacao Social e da Economia Criativa como Indutores para o Desenvolvimento Sustentável. International Journal of Knowledge, Engineering and Management, Vol. 3, N. 5, pp. 276-293. ISSN 2316-6517. Available at: http://stat.ijie.incubadora.ufsc.br/index.php/IJKEM/article/view/2687.

Feenstra, Gail. (2018). UC Sustainable Agriculture Research and Education Program, University of California, Davis. Available at: http://asi.ucdavis.edu/programs/sarep/about/what-is-sustainable-agriculture.

Food and Agricultural - FAO (2012). Environmental Impact Assessment (EIA): Guidelines for FAO Field Projects, ISBN 978-92-5-107276-9: http://www.fao.org/3/a-i2802e.pdf.

Food and Agricultural - FAO. (2011). Safe Food - Global Initiative on Food Loss and Waste Reduction. Available at: http://www.fao.org/docrep/014/mb060e/mb060e00.pdf.

Food and Agricultural - FAO. (2015). International Fund for Agricultural Development – IFAD; World Food Programme – WFP. Achieving Zero Hunger The critical role of investments in social protection and agriculture: http://www.fao.org/3/a-i4777e.pdf.

Freeman, Joshua. (2005). Towards a definition of holism. Br. J. Gen Pract; 55 (511): 154-155: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1463203/.

Gago, D. & Rubalcaba, L. (2007). Innovation and ICT in service firms: towards a multidimensional approach for impact assessment. Journal of Evolutionary Economics. Volume 17, Issue 1, pp 25-45, http://doi.org/10.1007/s00191-006-0030-8.

Gassmann, Oliver; Enkel, Ellen and Chesbrough, Henry. (2010). The Future of Open Innovation. R&D Management, https://doi.org/10.1111/j.1467-9310.2010.00605.x.

Gatherer, Derek. (2010). So what do we really mean we say that systems biology is holistic? BMC Systems Biology. 4:22/DOI 10.1186/1752-0509-4-22. http://bmcsystbiol.biomedcentral.com/articles/10.1186/1752-0509-4-22.

Georghiou, Luke; Smith, Keith; Toivanen, Otto Toivanen; and Yla-Anttila. (2003).Evaluation of the Finnish Innovation Support System. Ministry of Trade and Industry of Finland, Publication 5 May/2003. Available at http://ktm.elinar.fi/ktm_jur/ktmjur.nsf/All/172616819C0174ECC2256D2B003CA685/$file/ju5teoeng.pdf.

Geyer, Felix and Zouwen, Hans van der. (1992). Sociocybernetics and Applied Systems. CV Negoita ed, pp. 85-96.

Global Report Initiative – GRI. (2017). Website, Empowering Sustainable Decisions. https://www.globalreporting.org/information/sustainability-reporting/Pages/default.aspx.

Goldstein, Harvey and Renault, Catherine. (2004). Contributions of Universities to Regional Economic Development: A Quasi-experimental Approach .Regional Studies: The Journal of the Regional Studies Association, Volume 38, Number 7, October 2004, pp.733-746(14). Publisher**:** Routledge, part of the Taylor & Francis Group, https://doi.org/10.1080/0034340042000265232.

Grant, J. (2006). *Measuring the Benefits from Research*. RAND Europe (Pubd online). Available at : <http://www.rand.org/pubs/research_briefs/2007/RAND_RB9202.pdf> accessed 06/01/2018.

Greenacre, Philip; Gross, Robert and Speirs, Jamie. (2012). Innovation Theory: A review of the literature Imperial College Centre for Energy Policy and Technology. Available at: https://workspace.imperial.ac.uk/icept/Public/Innovation%20review%20-%20ICEPT%20working%20paper%20version%20(16.05.12).pdf, accessed 02/25/2018.

Grey, D.; Garrick, D.; Blackmore, D.; Kelman, J.; Muller, M.; Sadoff, C. (2015). Water security in on blue planet: twenty-first century policy challenges for science. Philosophical Transactions of the Royal Society, June 22, pp 1-10.

Guattari, Felix. (2015). Transdisciplinarity Must Become Transversality. https://doi.org/10.1177/0263276415597045. Theory, Culture & Society, 2015 – Vol. 32 (5-6), 131-137.

Hadorn, Gertrude Hirsch and Pohl, Christian . (2007).Principles for Designing Transdisciplinary Research. ISBN-13: 978-3-86581-046-5, Oekon Edition, Munich (Germany).

Hallsted, Sophie I.; Thompson, Antony W.; Lindahl, Pia. (2013). Key Elements for Implementing a Strategic Sustainability Perspective in the Product Innovation Process. Journal of Cleaner Production, volume 51, pp 277-288, http://doi.org/10.1016/j.jclepra2013.01.043.

Hanjra, Munir A. and Qureshi, M. Ejaz. (2010). Global Water Crisis and Future Food Security in an Era of Climate Change. Food Policy, Volume 35, Issue 5, pp. 365-377, http://doi.org/10.1016/j.foodpol.2010.05.006.

Hearn, Simon and Buffardi, Anne L. (2016). 'What is impact?'. A Methods Lab publication. London: Overseas Development Institute, www.odi.org.

Heckman, James J. (2006).Discussion Paper n°2184, University of Chicago and IZA Bonn, http://ftp.iza.org/dp2184.pdf.

Huge, Jean and Waas, Tom. (2011). Converging impact assessment discourses for sustainable development: the case of Flanders, Belgium. Environ Dev Sustain (2011) 13:607–626, DOI 10.1007/s10668-010-9279-z.

Impact Assessment Institute - IAI. (2017). Availabe at: http://www.impactassessmentinstitute.org/about.

Innovation Management - IM. (2013). Cultivating Engagement In Innovation Networks. Available at : http://www.innovationmanagement.se/2012/11/15/cultivating-engagement-in-innovation-networks/.

Institut National de la Recherche Agronomique - Inra. (2016). Impact societal de la recherche. Available at : https://www6.inra.fr/asirpa, accessed 03/15/2019.

Institut National de la Recherche Agronomique – Inra. (2015). Bilan Social 2015. Available at : https://inra-dam-front-resource-cdn.brainsonic.com/ressources/afile/376752-a0a48-resource-bilan-social-2015.pdf, accessed 03/20/2018.

International Organization for Standardization - ISO. (2015). Introduction to ISO 14001- https://www.iso.org/files/live/sites/isoorg/files/archive/pdf/en/introduction_to_iso_14001.pdf.

Iribarry, I. N., 2001. O diagnostico transdisciplinar em psicopatologia (ensaios de Analitica Existencial, Metapsicologia e Apresentacao Psicanalitica de Pacientes enquanto fundamentos de sua demonstracao). Universidade Federal do Rio Grande do Sul. Porto Alegre, RS. Available at : https://pt.scribd.com/document/77336535/transdisciplinaridade, accessed 03/21/2018.

ISRIA – The International School on Research Impact Assessment. (2017). ISRIA website. Available at: http://theinternationalschoolonria.com/, accessed 04/12/2018.

Japiassu, H e Marcondes, Danilo. (1989). Pequeno dicionario de filosofia. Jorge Zahar Ed. Sao Paulo.

Joly, Pierre Benoit, Laurence Colinet, Ariane Gaunand, Stephane Lemarié, Mireille Matt. (2016). Agricultural research impact assessment: issues, methods and challenges. [Research Report] auto-saisine. 2016, 51p. <hal-01431457>. Available at: https://hal.archives-ouvertes.fr/hal-01431457/document, accessed 03/03/2018.

Jonkers, K., Tijssen RJW, Karvounaraki, A., Goenaga, X, A. (2018). Regional Innovation Impact Assessment Framework for universities; EUR 28927 EN; Publications Office of the European Union, Luxembourg, 2018; ISBN 978-92-79-77048-7; doi:10.2760/623825; JRC109020.

Junior, Wilson Correa; Filho, Roberto Penteado; Vedovoto, Graciela; Marques Daniela; Avila, Antonio Flavio. (2014). Balanço Social 2014 – Manual de Instruções. Secretaria de Gestão e Desenvolvimento Institucional – SGI. Available at: www.embrapa.br/balanço social.

Kemmis, S. & Mctaggart, R. (2000). Participatory action research. Em N. Denzin & Y.S. Lincoln, Handbook of qualitative research (pp. 567-606). London: Sage Publications Inc.

Kuby, T., 1999. Innovation as a Social Process: What Does this Mean for Impact Assessment in Agricultural Research. Paper presented at a CIAT workshop, Costa Rica, September 1999.

Kuhn, Thomas. (2012). The Structure of Scientific revolution. Chicago, University of Chicago Press. ISBN – 10:0-226-45812-1.

Law, A.M. and Kelton, W.D. (1991). Simulation Modelling and Analysis. 2nd Edition, McGraw-Hill, New York.

Loorbach, Derk and Rotmans, Jan. (2010). The practice of transition management: Examples and lessons from four distinct cases. Futures 42, pp 237-246. Available at: https://www.researchgate.net/publication/222518552_The_practice_of_transition_management_Examples_and_lessons_from_four_distinct_cases [accessed Apr 26, 2017].

Markard, Jochen; Raven, Rob and Truffer, Bernhard. (2012). Sustainability.transitions: An emerging field of research and its prospects. Research Policy Volume 41, Issue 6, July 2012, Pages 955–967. Available at: http://www.sciencedirect.com/science/article/pii/S004873331200056X.

Markus, Lynne M.; Majchrzak, Ann; Gssser, Les. (2002). A Design Theory for Systems that Support Emergent Knowledge Processes. MisQuarterly – Special Issue. Vol. 26, No. 3 (Sep., 2002), pp. 179-212. Published by Management Information Systems Research Center, University of Minnesota.

MasterQResearch. (2012). Socio-Economic Impact Assessment as part of the Environmental Impact Assessment Process for the Proposed Thyspunt Lines Integration Project DWEA Ref. No. 12/12/20/1212: Northern Corridor the construction and operation of 3x 400kV transmission power lines: 1x Thyspunt Grassridge and 2x Thyspunt – Dedisa, South Africa, Dec 2010.

Mediamax. (2016). 10 world's leading food producing countries. Available at: http://www.mediamaxnetwork.co.ke/261583/261583/.

Mendonca, S. J. B. (2016). Sustainable Solutions for Tropical Agriculture: Brazilian experiences 43. In: Meybeck, A. and Redfern, S.; Knowledge and Information for Sustainable Food Systems. Roma: Food and Agricultural Organisation of the United Nations – FAO. Available at: ww.fao.org/3/a-i5373e.pdf.

Mergaert, Lut and Minto, Rachel. (2015). Ex-Ante and Ex-Post Evaluations: two sides of the same coin? – The Case of Gender Mainstreaming in EU Research Policy. Symposium on Policy Evaluation in the EU. European Journal of Risk Regulation – EJRR/1, 47, DOI: 10.1017/S1867299X0000427X.

Merrey, D.J. (2015). An Evaluation of CGIAR Centers' Impact Assessment Work on Irrigation and Water Management Research. Rome, Italy, Standing Panel on Impact Assessment (SPIA), CGIAR Independent Science and Partnership Council (ISPC). 83 pp.

Metherbe, J.C. Conceito de Sistemas. (1986). Análise de sistemas, Rio de Janeiro, Ed. Campus, pp.31-43.

Minayo, M.C. de S., Deslandes, S.F.; Neto, O.C. & Gomes, R. (2000). Pesquisa social teoria método e criatividade. Petrópolis: Vozes.

Ministerio da Agricultura, Pecuaria e Abastecimento – Mapa. (2018). Assuntos: Sustentabilidade, Plano ABC. Institutional main site, available at: www.agricultura.gov.br.

Morin, Edgar et Le Moigne, Jean-Louis. (2003). L'intelligence de la complexité. Ed. L'Harmallan, France. EAN13: 9782738480859.

Morin, Edgar. (1990). Science avec conscience, Paris: Edition Seuil, pp 36-38.

Mulej, Matjaz ; Kajzer, Stefan ; Potocan, Vojko ; Rosi, Bojan and Knez-Riedl, Jozica. (2006). Interdependence of systems theories – potential innovation supporting innovation. Kybernetes, Vol. 35 Issue: 7/8, pp.942-954, https://doi.org/10.1108/03684920610675003.

Mumford, Michael D.; Zaccaro, Stephen J.; Harding, Francis D.; Jacobs, Owen T. and Fleishman, Edwin A. (2000). Leadership skills for a changing world: Solving complex social problems. The Leadership Quarterly. Volume 11, Issue 1, Spring 2000, Pages 11-35, https://doi.org/10.1016/S1048-9843(99)00041-7.

Mumford, Troy V.; Campion, Michael A.; Morgeson, Frederick P. (2007). The leadership skills strataplex: Leadership skill requirements across organizational levels. The Leadership Quarterly, Volume 18, Issue 2, April 2007, Pages 154-166, https://doi.org/10.1016/j.leaqua.2007.01.005.

Mutz, Rudiger; Bornmann, Lutz and Daniel, Hans-Dieter. (2015). Cross-disciplinary research: What configurations of fields of science are found in grant proposals today?, *Research Evaluation*, Volume 24, Issue 1, 1 January 2015, Pages 30–36, https://doi.org/10.1093/reseval/rvu023.

National Institute of Statistics and Economics Studies of France - INSEE. (2016). https://www.fr/en/metadonnees/definition/c1182.

Naylor, S. & Keogh, B. (1999). Constructivism in classroom: Theory into practice. Journal of Science Teacher Education, 10, 93-106.

NCVO - The National Council for Voluntary Organisations, England. (2017). Written by Dr Richard Piper. Available at : https://knowhownonprofit.org/organisation/impact/about-impact-and-evaluation/understanding-the-language. Published in 02/2017 with permission from NCVO.

Nidumolu, Ram; Prahalad, C.K.; Rangaswami, M.R. (2009). Why Sustainability Is Now the Key Driver of Innovation. Harvard Business Review, September 2009. Available at: https://hbr.org/2009/09/why-sustainability-is-now-the-key-driver-of-innovation.

Oetzel, John and Ting-Toomey, Stella. (2006). The Sage Handbook of Conflict Communication – Integrating Theory, Research, and Practice. Sage Publications, London.

Oliveira, Talita Moreira de; Amaral, Livio; Pacheco, Roberto Carlos dos Santos. (2018). Multi/inter/transdisciplinary assessment: A systemic framework proposal to evaluate graduate courses and research teams, *Research Evaluation*, rvy013, https://doi.org/10.1093/reseval/rvy013.

Olshavsky, Richard W. and Spreng, Richard A. (1996). An Exploratory Study of the Innovation Evaluation Process. The Journal of Product Innovation Management, http://doi.org/10.1111/1540-5885.1360512.

Organisation for Economic Co-Operation and Development - OECD. (2002). Glossary of Key Terms in Evaluation and Results Based Management. Available at: http://bit.ly/1KG9WUk.

O'Sullivan, D. (2008) Applying Innovation. : Sage Publishing, Thousand Oaks, California, pp 3.

Oxford Dictionary. (2015).The impact of BAE systems on the UK economy. Available at: www.oxfordeconomics.com.

Oxford Dictionary. (2018). English Dictionary. Available at: https://en.oxforddictionaries.com/definition/impact; https://en.oxforddictionaries.com/definition/political. Accessed on 08/02/2018.

Oxford Economics. (2013).The economic impact of Starbucks on the UK economy. A report for Starbucks. Available at: www.oxfordeconomics.com.

Penfield, Teresa; Baker, Matthew J.; Scoble, Rosa; Wykes, Michael C. (2014). Assessment, evaluations, and definitions of research impact: A review. Research Evaluation, Volume 23, Issue 1, 1 January 2014, Pages 21–32,https://doi.org/10.1093/reseval/rvt021.

Piaget, Jean. (1967). Logique et connaissance scientifique. Encyclopédie de la pléiade ; n 23. Paris: Gallimard.

Piaget, Jean. (1972). Epistemologie des relations interdisciplinaires. In: CERI (EDS.) L'interdisciplinarité. Problèmes d´enseignement et de recherche dans les Universités, p. 131-144. Paris: UNESCO/OCDE.

Pisano, Umberto; Lange, Lisa and Berger, Gerald. (2015). Social Innovation in Europe An overview of the concept of social innovation in the context of European initiatives and practices. ESDN Quarterly Report N°36, April 2015. European Sustainable Development Network - Institute for Managing Sustainability. Vienna University of Economics and Business. Available at: http://www.sd-network.eu/quarterly%20reports/report%20files/pdf/2015-April-Social_Innovation_in_Europe.pdf.

Planing, Patrick. (2017). On the origin of innovations—the opportunity vacuum as a conceptual model for the explanation of innovation. Journal of Innovation and Entrepreneurship 6:5 DOI 10.1186/s13731-017-0063-2.

Popa, Florin; Guillermin, Mathieu and Dedeurwaerdere, Tom. (2015). A pragmatist approach to transdisciplinarity in sustainability research: From complex systems theory to reflexive science. Futures 65 pp. 45–56, 0016-3287/Published by Elsevier Ltd. This is an open access article under the CC BY license. Available at: http://creativecommons.org/licenses/by/ 3.0/.

Pope, Jenny; Annandale, David and Morrison-Saunders, Angus. (2004). Conceptualising sustainability assessment. Environmental Impact Assessment Review 24, 595–616. http://ac.els-cdn.com/S0195925504000447/1-s2.0- S0195925504000447-main.pdf?_tid=1bc3edf0-0f22-11e7-86cd-00000aab0f6c&acdnat=1490202662_8e77bd6cf1bcb0a97eae8ef4b1359772.

Powell-Morse, Andrew. (2017). Conceptual Models – What Are They and How Can You Use them? Available at: https://airbrake.io/blog/sdlc/conceptual-model.

Rahim, Afzalur M. (2017). Managing Conflicts in Organizations, pp. 2-18; pp. 18-30. Ebook ISBN 9781351507288. Routledge. 4th edition. New York.

Raymond, Jeanette (2008)."Benchmarking in public procurement", Benchmarking: An International Journal, Vol. 15 Iss 6 pp. 782 – 793.

Reale, Emanuela; Avramov, Dragana; Canhial, Kubra; Donovan, Claire; Flecha, Ramon; Holm, Poul; Larkin, Charles; Lepori, Benedetto; Mosoni-Fried, Judith; Oliver, Esther; Primeri, Emilia; Puigvert, Lidia; Scharnhorst, Andrea; Schubert, Andràs; Soler, Marta; Soos, Sandor; Sorde, Teresa; Travis, Charles; Van Horik, Rene. (2017). A review of literature on evaluating the scientific, social and political impact of social sciences and humanities research. *Research Evaluation*, rvx025, https://doi.org/10.1093/reseval/rvx025.

Rodrigues, Geraldo Stachetti ; Buschinelli, Cláudio and Avila, Antonio Flavio. (2010). An Environmental Impact Assessment System for Agricultural Research and Development II: Institutional Learning Experience at Embrapa. Journal of Technology Management & Innovation
J. Technol. Manag. Innov., Volume 5, Issue 4 p.38-56. Available at: http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-27242010000400004.

Rodrigues, Geraldo Stachetti; Campanhola, Clayton and Kitamura, Paulo Choji. (2003). Avaliaçao de Impacto Ambiental de Inovaçao Tecnologica Agropecuaria: AMBIEC-AGRO. 95p, Embrapa Meio Ambiente - Documentos, 34, ISSN 1516-4691. Available at : http://www.cnpma.embrapa.br/download/documentos_34.pdf.

Rogers, E.M.. (1995). Diffusions of Innovations, p. 247, 3rd edition. Free Press, New York.

Rogers, Todd; Goldstein, Noah J., and Fox, Craig R. (2018). Social Mobilization. Annual Review of Psychology. DOI: 10.1146/annurev-psych-122414-033718. Available at: http://www.annualreviews.org/page/journal/pubdates for revised estimates.

Roquete, Fátima; Amorim, Maria ; Barbosa, Simone ; Souza, Danielle ; Carvalho, Vilma. R. Enferm. (2012). Dialogue among knowledge: multidisciplinarity, interdisciplinarity and transdisciplinarity in public health field. Cent. O. Min. set/dec 2012; 2(2):463-474. ISSN: 2236-6091, DOI: 10.19175. Available at: http://seer.ufsj.edu.br/index.php/recom/article/view/245/360.

Ruegg, R. & Feller, I. (2003). A Toolkit for Evaluating Public R&D Investment: Models, Methods, and Findings from ATP's First Decade., Gaithersburg: National Institute of Standards and Technology. Available at: ftp://ftp.earthobservations.org/GEOSS%20Midterm%20Evaluation/Document%20Analysis/Potential%20Evaluation%20Methods/ID1.A%20Toolkit%20for%20Evaluating%20Public%20R&D%20Investment%20Models,%20Methods,%20and%20Findings%20from%20ATP%27s%20First%20Decade/A%20Toolkit%20for%20Evaluating-1.pdf.

Ruttan, V. W. (2001).Technology, Growth and Development: An Induced

Sadler, B. and Verheem, R. (1996) Strategic Environmental Assessment: Key Issues Emerging from Recent Practice. Ministry of Housing, Spatial Planning and the Environment, The Hague.

Saito, C. H. (2017). Quais seriam as questoes globais que desafiam a educacao ambiental? Para alem do modismo, uma analise sistematica e uma visao sistemica. Revista Eletronica do Mestrado em Educacao Ambiental, V. Especial, pp 4-24, 2017.

Saqib, Shahnawaz; Abrar, Muhammad; Sabir, Hazoor M.; Bashir, Mohsin; Baig, Sajjad A. (2015). Impact of Tangible and Intangible Rewards on Organizational Commitment: evidence from the textile sector of Pakistan. American Journal of Industrial and Business Management, 2015-5, 138-147, http://dx.doi.org/10.4236/ajibm.2015.53015.

Scholz, R.W.; Mieg, H.A.; Oswald, J.E. (2000). Transdisciplinarity in groundwater management – Towards mutual learning of science and society. Water, Air, & Soil Pollution, 123 (1–4), pp. 477–487. Available at: http://www.sciencedirect.com/science/article/pii/S0016328714001906.

Schumpeter, J. A. (1983). The theory of economic development.Transaction Publishers, New Brunswick, New Jersey, USA, pp. 112-160. Original material copyright 1934 by the President and Fellows of Harvard College. ISBN: 978-0-87855-698-4.

Stanleigh, Michael. (2017). From Vision To Reality: The Innovation Process. Business Improvement Architects. Available at: https://bia.ca/from-vision-to-reality-the-innovation-process/.

The Commonwealth Scientific and Industrial Research Organisation – CSIRO. (2017). Assessment of CSIRO Impact and Value 2014. Available at: https://www.csiro.au/en/About/Our-impact/Reporting-our-impact/Performance-review/2014-impact-assessment, accessed 03/23/2018.

The Commonwealth Scientific and Industrial Research Organisation – CSIRO. (2015). Impact Evaluation Guide. Available at: www.csiro.au, accessed 03/22/2018.

The Review Board. (2007). Socio-Economic Impact Assessment Guidelines. Mackenzie Valley Environmental Impact Review Board: http://www.reviewboard.ca/upload/ref_library/SEIA_Guidelines_Contents_and_Chapter_1.pdf.

The United Nations Children's Fund - Unicef. (2015). Communication for Development: Social Mobilization. Available at: https://www.unicef.org/cbsc/index_42347.html.

Thomas, K. W., & Schmidt, W. H. (1976). A Survey of Managerial Interests with Respect to Conflict. Academy of Management Journal, 19, 315-318. http://dx.doi.org/10.2307/255781.

Todorov, Joao Claudio. (2004). Da Aplysia à Constituição: Evolução de Conceitos na Análise do Comportamento. Paper presented at the 54th Annual Meeting of the Brazilian Society for the Progress of Science, Goiânia, Goiás, July 2002. Psicologia: Reflexão e Crítica, 2004, 17(2), pp.151-156.

United Nations – UN. (1987). UN – United Nations. (1987). Our Common Future Report, March 1987. Available at: http://www.un-documents.net/our-common-future.pdf, accessed 03/11/2018.

United Nations – UN. (1992). Agenda 21, Item 8.3 – Sustainable Development. United Nations Conference on Environment & Development Rio de Janerio, Brazil, 3 to 14 June 1992. Available at: https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf, accessed 03/11/2018.

United Nations – UN. (2010). Sixty-fifth session Agenda items 13 and 115 10-51260 - Resolution adopted by the General Assembly. Available at: http://www.un.org/en/mdg/summit2010/pdf/outcome_documentN1051260.pdf.

United Nations – UN. (2015). 23RD UN/INTOSAI Symposium UN Post-2015 Development Agenda: The Role of SAIs and Means of Implementation for Sustainable Development. Department of Economics and Social Affairs. Available at: http://www.un.org/en/development/desa/usg/statements/mr-wu/2015/03/23rd-unintosai-symposium.html.

United Nations – UN. (2017). The United Nations Conference on Trade and Development – UNCTAD. New Innovation Approaches to Support the Implementation of the Sustainable Development Goals. Available at: unctad.org/en/PublicationsLibrary/dtlstict2017d4_en.pdf, accessed 03/01/2018.

United Nations - UN. (2019). Transforming our world: the 2030 Agenda for Sustainable Development. General Assembly. Resolution adopted by the General Assembly on 25 September 2015 (seventieth session). Available at: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.

United Nations Development Group – UNDG (2011) Results-Based Management Handbook. Available at: https://undg.org/wp-content/uploads/2014/06/UNDG-RBM-Handbook-2012.pdf.

United Nations Environment Programme - UNEP /SETAC. (2011).Towards a life cycle sustainability assessment: Making informed choices on products.Life Cycle Initiative. ISBN: 978-92-807-3175-0, Job Number: DTI/1412/PA.

United Nations Environment Programme – UNEP. (2004). Environmental Impact Assessment and Strategic Environmental Assessment: Towards an Integrated Approach. Edited and published by UNEP, Geneva. Available at: http://www.unep.ch/etu.

Verheem R. (2002). Recommendations for Sustainability Assessment in the Netherlands. In Commission for EIA. Environmental Impact Assessment in the Netherlands. Views from the Commission for EIA in 2002. The Netherlands.

Von Schomberg R. (2012). Prospects for Technology Assessment in a Framework of Responsible Research and Innovation. IN: Dusseldorf M., Beecroft R. (eds) Technikfolgen abschatzen lehren, pp 39-61. VS Verlag fur Sozialwissenschaften, http://doi.org/10.1007/978-3-531-93468-6_2.

Vygotsky, L. S. (1978). Tool and symbol in child development. In M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (Eds.). Mind in Society: The development of higher psychological processes. Cambridge, Mass: Harvard University Press.

Walker, Richard M. (2007). An Empirical Evaluation of Innovation Types and Organizational and Environmental Characteristics: Towards a Configuration Framework. Journal of Public Administration Research and Theory, Volume 18, Issue 4, 1 October 2008, Pages 591–615, https://doi.org/10.1093/jopart/mum026.

Weckowicz, Thaddus E. (1989). A Pioneer of General Systems Theory. Center for Systems Research Working Paper No. 89-2. Edmonton AB: University of Alberta. Available at: http://www.richardjung.cz/bert1.pdf.

Weisbrod, Glen and Burton. (1997). "Assessing the Economic Impacts of Transportation Projects", published in 1997 by the National Academy of Science / Transportation Research Board as Transportation Research Circular #477, Boston, MA, USA. Available at : http://www.edrgroup.com/pdf/econ-impact-primer.pdf.

Wernham, Aaron. (2011). Health Impact Assessments Are Needed In Decision Making About Environmental And Land-Use Policy. Health Aff, May 2011, 30:5947-956; doi:10.1377/hlthaff.2011.0050. Available at: http://content.healthaffairs.org/content/30/5/947.full.

White, H. (2010) A contribution to current debates in impact evaluation. Evaluation, 16(2): 153-64.

Wilmot, W. & Hocker, J. (2001). Interpersonal conflict (6th ed). Dubuque, IA: William C. Brown.

World Health Organization – WHO 1948 Constitution of the World Health Organization. (2006). Geneva: World Health Organization, Basic Documents, Forty-fifth edition, Supplement, October 2006. Available at: http://www.who.int/governance/eb/who_constitution_en.pdf.

Zscheischler, Jana; Rogga, Sebastian and Lange, Andrej. The success of transdisciplinary research for sustainable land use: individual perceptions and assessments. (2018). Sustainability Science 13:1061–1074, https://doi.org/10.1007/s11625-018-0556-3.

Attachments

Annex 1: Field Experience Data and Information

This annex contains data and information captured on the field experience, which it was held with Embrapa's agricultural research and innovation stakeholders. Here are the groups of stakeholders interviewed and with whom meetings were held, as well as information on visits to farms, such as samples. They were divided into two groups, one external (farmers, representatives of rural extension workers, representatives of the bank that finances the agricultural production and so on), and one internal to Embrapa and Ministry of Agriculture.

About the external group, it is worth mentioning that representatives of organizations in the agribusiness sector are spokespersons for rural producers throughout Brazil (in the case of the National Confederation of Agriculture and Livestock - CNA). CNA represents a system of all rural producers in Brazil. Constituted in a pyramidal way, it has at its base 1,951 registered Rural Unions and 1,122 deployments or local extensions of these unions[8].

***Internal Groups*:**

- Embrapa's researchers, and;
- Coordination for ABC Plan of the Ministry of Agriculture, Livestock and Supply (in Ministry headquarters) and coordination for local ABC Plan dissemination of the Federal Superintendence of Agriculture in the State of Mato Grosso.

External Groups:

- National Confederation of Agriculture and Livestock - CNA;
- State of Mato Grosso Federation of Agriculture and Livestock - Famato;
- Institute of Agricultural Economics of Mato Grosso – Imea (organization linked to the Famato);
- Bank of Brazil - Lucas do Rio Verde Agence, MT;
- Five farms that adopt Embrapa's technologies which make part of ABC Plan – in the municipalities of Sinop, Santa Carmen, Lucas do Rio Verde, Ipiranga do Norte,

[8] Reference: CNA, 2019. Available at: https://www.cnabrasil.org.br/cna/contribui%C3%A7%C3%A3o-sindical-rural-2018.

and Alta Floresta. And other five farms that do not adopt ABC Plan technologies, being one in the municipality of Ipiranga do Norte, another in Nova Guarita and the others three in Alta Floresta, all of them in the State of Mato Grosso.

Field Experience Operational Activities

By following the fixed methodology, several activities were accomplished during the field survey, like meetings and interviews, in several specific moments during the period of July/November 2017 and Mai/July 2018 (including new contacts with the same people interviewed for fine-tuning data and information):

- Meeting and semi-structured interviews (by using open questions) with Embrapa's team, in Brasilia, Sinop, Rio de Janeiro and Jaguariuna, where are located Embrapa's research units and with the national coordination for ABC Plan of Ministry of Agriculture, Livestock, and Supply, in Brasilia;
- Meeting and a semi-structured interview (by using open questions) with Coordination for Sustainability of National Agricultural Confederation of Agriculture and Livestock, in Brasilia;
- Meeting and a semi-structured interview (by using open questions) with the Agricultural and Livestock Federation in the State of Mato Grosso - Famato, in Cuiaba, MT;
- Meeting and scripted interview (by using open questions) with Banco do Brasil team at a local agency in Lucas do Rio Verde, MT;
- Meeting and semi-structured interview (and unstructured interviews) for data collection with five farmers that adopt technologies of ABC Plan;
- Meeting and semi-structured interview (and unstructured interviews) for data collection with five farmers that do not adopt technologies of ABC Plan;
- Meeting with IMEA (Institute for Agricultural Economics of State of Mato Grosso, organization linked to the Famato) technicians for collecting data and information related to the economic impact of ABC Plan by producers' vision and capture of added data for state government.

Research Adopted Instruments

There was a reinforcement of capturing some more data and information on the field, as well as there were contacted six private organization that works with rural technical assistance in northern Mato Grosso. From them, only three positively answered with dialogue and interview and just one has filled out a quiz that was them demanded.

Beyond local farm visits by on-site observation, and analysis of satellite images of the region and farms, were adopted open questions and unstructured interviews, as well as formal meetings, were used two specific types of script interview (all models are attached in the final of this thesis):

- one group of questions for farmers (62 closed and open questions about economic, social and environmental aspects, beyond the farm identification); and
- another one for technical assistance workers (17 closed and open questions addressing issues related to its relationship with the research, farmers, and banks for rural credit).

The Bank, CNA and producers' representative in Mato Grosso were interviewed by a semi-structured interview (using a general script) related to their opinions about ABC Plan (in financial and technological access, and on management performance) and on technology impacts presented by Embrapa, as well as on relationship with rural extension.

The form that based on interviews for farmers (with 62 questions) adopted an evaluation scale from "0" (zero) which represents "without data for being assessed", 1 that means "very low impact or fact never happened"; 2 means low impact; 3 reasonable impact or medium degree of impact; 4 means good; and 5 very good impact.

Note: In the following sub-items it is possible to verify the occurrence of signs that identify an itemization (**a marker**), which indicate the comments, answers or aspects considered in interviews and data collection, and soon after that has the description of "**Analysis**" that is the analytical inference on such questions answered or observed in the field.

Summary of the Farmers Interviews among the ABC Plan Users

Four of them adopt two of the technologies of the ABC Plan, namely, no-tillage system and crop-livestock integration. One of them adopts livestock-forest. The adoption of no-tillage and crop-livestock integration represents the majority of producers who use the ABC Plan as a financing mechanism for production, which forces them to adopt one or more of the sustainable technological solutions proposed by Embrapa. No-tillage has been routine practice in the state of Mato Grosso, and this is positive from improvements in the physical, chemical and biological quality of the soil, proven in the experiments of Embrapa.

Direct planting and crop-livestock integration, in dialogue with local producers and industry representatives, is already a step forward regarding sustainable practices since in the past there was stabilization and culture already settled in monocultures or rotation soy-corn. Now, with integration grains with pasture and livestock, it is clear the advantages and benefits to the quality of the soil, besides the economic advantages for the producer, as it diversifies its range of products to be offered to the market, minimizing volatilities of grain prices, and it has been verifying production cost reduction.

The inclusion of the forest component in the integrated system brings even more benefits in terms of animal welfare (the cattle like the trees' shadow), reduction of moisture loss in the soil, keeping grassland greener, even in drier seasons of the year and further extends the range of product diversification to be offered to the market, in this case wood.

However, there is still some resistance on the part of producers to integrate the forest component and, one of the factors they express is the time that they have to wait for the economic return. There is a need to expand the dissemination of this system by using creative communication ways (by the Ministry of Agriculture and Embrapa), including the forestry component, to sensitize and mobilize a greater number of producers to adopt this sustainable and more profitable production alternative:

Four of the farmers have known about ABC Plan, and its funds through Banco do Brasil staffs, and one of them has known of the ABC Plan by the Embrapa's researchers.

The fact that most of the producers are aware of the ABC Plan through the Bank that finances their production seems coherent since the bank staff informs them about the new loan modalities when they go to the financial institution for credit. The fact that Embrapa participates with a low level of disclosure denotes the relative proportionality consistent with the mission of a research organization, in spite of the innovation requiring a closer dialogue with its stakeholders, which includes the closest clients. With this, Embrapa should expand forms of dissemination of this policy and the technological solutions available for its viability.

There is, however, a huge gap between research, technical assistance and rural extension and the banks, perhaps requiring more dialogue between these actors and a joint action to spread the politics and the technologies added to them. Technical assistance is a key part of this value chain and does not appear to be properly aligned with other partners especially with the research.

Farmers would expect for greater dialogue with researchers since many producers end up doing empirical research and observing the results of their experiences or practices on the ground and during operation of their production system, which could help the researcher. Indeed, despite without clear expression, they would like another method of interrelationship, that is, a type of method called action-research method which creates dynamism and fast exchange and answers among researchers and researched groups and could help researchers and producers and vice versa, into a participatory, positive and constructive way for innovation. It is worth mentioning; this is an important aspect considered by Impress process conducted by Cirad.

The use of diversified methods of information collection was important. The semi-structured interview and within a formal climate had its validity, but with biases that were only observed when the second moment of the unstructured interview took place, in a more informal atmosphere, at which time the interviewees could expose some issues with a greater degree of truthfulness. One of them was the strong criticism about the Brazilian Forest Code and the restrictions related to the Legal Reserve, which reaches 80% in the Amazon biome and 35% in the Cerrados, restricting the production of grains, cotton, and livestock in these areas, even adopting sustainable systems such as integrated models.

In order to access the ABC Plan's credits, the owner is obliged to show that he is legally able to contract the loan because he is complying with the environmental law on the reserves he must preserve within the farm (the Brazilian Forest Code, which regulates land use). The legality of ownership means that it is registered in the Rural Environmental Registry, coordinated by the federal government through the Brazilian Forest Service.

They argue that only the permanent preservation area, which already has very strict rules (which most of the countries of the world that compete with Brazil in the international agricultural market do not have), and these restrictions already represent a great contribution of the rural producer to the environment. There is unanimity that the areas of permanent preservation are essential for environmental protection and this already represents an advance in their level of environmental awareness.

The ABC Plan success, as well as the environmental rules, depending on the stakeholders' mobilization, engagement towards this policy implementation and it demands that conflicts are managed, and actors are in the higher level of sustainability awareness.

It would be naive to think that environmental consciousness would come only through the maturity of consciousness itself. Government and research need to be more assertive in showing the economic advantage of being sustainable and proving it. This requires that government sectors, including research and innovation, develop economically viable solutions for the use and management of natural resources, with added value, with support in marketing and market opening plans in the country and in the world for these sustainable products, with green labelling, including solutions in the field of agroforestry systems with native species and their bioproducts.

It was clear that technical assistance needs to better orientate producers for sustainable solutions in managing natural resources and their agricultural systems by complying environmental legislation and searching for sustainable practices simultaneously capturing new niches of the market for increasing profitability. In this way, the research must have complicity in these responsibilities and commitments too.

All of them were unanimous in affirming that the adoption of the technologies proposed by the ABC Plan, especially about the no-till system and crop-livestock integration are very positive and have improved their profitability, quality of life of them and their families. Considering the improvement of farmers profitability, it naturally generates positive consequences for the quality of health and education, especially for their family.

When everyone says that the adoption of the sustainable technologies proposed by the ABC Plan improved their quality of life due to cost reduction with production, productivity improvement, and revenue increase (even in cases where the owner not raised funds from the specific rural credit for this purpose), shows a positive impact in the social field. Social indicators could be much broader and more explored and verified, however, the cut of this survey was very narrow and focused on the components of education, health, and improvement of the quality of life, and all stated that due to the increase in income, these components also received minor improvements. The impact was not greater, according to them, due to the increase in the cost of agricultural inputs, which greatly amortized the profitability.

Summary of the Farmers Interviews among the ABC Plan non-Users

Among non-users of the ABC Plan technologies, five farmers were interviewed, by using a semi-structured script (the same instrument used for ABC Plan users). Among those interviewed: one has his farm in Ipiranga do Norte, another in Nova Guarita and three of them in Alta Floresta, all of them located in the north of the State of Mato Grosso. The following is a summary of the interviews. None of the farmers live on their farms, although the farms have a structure for some personnel who live there.

All of them said that they had superficial contact with the ABC Plan through the Banco do Brasil, but that interest rates are high which discourage them from obtaining official rural credits. They have said that they resent support from the technical assistance and rural extension, and this problem provokes afraid of facing plantation and livestock risks by using new technologies. Only two farmers plant soybean and corn, by adopting crop rotation and no-tillage (because they already knew these techniques before the ABC Plan has been launched), they said that think are using correctly agricultural technologies. Other three farmers have livestock of beef cattle and do not fertilize the pasture or adopt any management that could promote the sustainability of pasture or soil.

In this item, many of the points discussed in the analyzes of the producers that use the ABC Plan are valid to be applied here. For example, it would be important for the Ministry of Agriculture, Embrapa, Banco do Brasil and Rural Technical Assistance to be more aligned with each other and to carry out a wide campaign of dissemination and mobilization of producers to engage in the ABC Plan. At the same time, the Plan would need to be reevaluated about bureaucratic mechanisms for accessing credit - in this case; banking institutions will be the key to finding simpler and easier solutions to operate.

All complained that the research is very far from the producer and that the situation worsens to the extent that there is no technical assistance and official rural extension. They said they feel the need for greater guidance not only in the technical but also managerial part of their farms. They said they want cheap and uncomplicated technologies and that the government should offer lower interest rates to the farmer with a longer payment term as well as using less bureaucratic credit systems.

All these producers were unanimous in stating that they feel it is important to protect the environment and that in this case, they affirmed that is essential to protect the permanent preservation areas (such as riparian areas). But, they were firmly against the legal imposition of new forest code which states that it is necessary that each property has a legal reserve of 80% for the Amazon, in addition to already protecting the permanent preservation areas. They feel penalized by this measure, and they no longer feel motivated to produce using more sustainable techniques because they do not have enough areas to do so.

Interviews with the Rural Technical Assistance Workers

The public or official technical assistance does not operate in rural zones of the state of Mato Grosso, only private institutions of technical assistance. To preserve the identity of the interviewees and, therefore, the confidentiality of the information provided, it was sought to summarize the interviews carried out by mixing the opinions of the technicians as the following.

For this group, a baseline quiz was used, in a semi-structured approach with open questions. Eleven interviews were conducted personally (face-to-face), three by phone and e-mail exchange and Skype.

One enterprise interviewed said that at present accomplishes research and give specific technical assistance to their associated members in livestock and crops, especially for various types of pasture, various species of leguminous, corn, cotton, finger millet and soy plantation. This company adopts few technologies from Embrapa, does adaptive research, tests new varieties from Embrapa and mainly from private companies, validates species in properties of associates. It understands that could be closer of Embrapa regarding elaboration and implementation of joint research projects for solving specific and urgent problems on plantation and livestock, including for integrated systems.

This company criticized the excess of governmental bureaucracy for carrying out partnerships with Embrapa, thus, gave up to make efforts with this public institution for carrying out joint projects, although sometimes receives some isolated support from individual Embrapa's researchers.

Other members of rural technical assistance companies said that each one of its organizations guides hundreds of properties, with technical, managerial guidelines and in the elaboration of projects to capture resources of the rural credit with banks, including in cases of renegotiation of bank debt. In the technical field, they guide the planting, handling, harvesting, and post-harvest of corn, soybean, cotton, and also in processes related to the dairy cattle and beef cattle livestock. These companies serve large, medium and small-scale producers. They usually make a weekly visit to the farms during the harvest period.

The rural technical assistance companies do not have direct contact with Embrapa and only receive technical guidance from the researchers when they are invited to specific lectures and field days on technological information. Technicians feel the same gap over bank credit information. Only when the Banco do Brasil (Bank of Brazil) informs them, or when they access the Banco Central (Central Bank of Brazil), the BNDES (National Development Bank) and Banco do Brasil websites, they can obtain detailed information about rural credit programs and policies.

About new technologies or even on no-till systems and crop-livestock-forest integration companies only received information and opportunities to get questions about technical issues, especially at the beginning of the ABC.

Among the companies consulted, all stated that there are no problems or difficulties to elaborate on the necessary projects, according to banking requirements to release agricultural credits. Two of the companies answered, however: "normally have been occurred delays due to lack of registration of the producer updated information in the Bank. Also, that has been observed lack of documentation required by the bank on the agricultural areas to be benefited; frequently inadequate lease terms on the areas for plantation; and lack of environmental licensing by the producer. It has been observed problems with the legal suitability of the producer to access the credit".

For concluding, briefly, rural technical assistance workers demands:

- a more direct interaction and communication channel via the Internet between Embrapa and them, with general videoconferences or by clients, with a demonstration of technological solutions that can attend specific micro-regions and not with general formulas for the State or the Country, in face of climatic and soil specificities and factors related to certain biomes and local ecosystems;
- it is necessary to improve and expand the number of training on how to design projects, by the technical parameters;
- Reducing bureaucracy is necessary to facilitate formal partnerships between Embrapa and private partners interested in joint research.

The Banking Institution Interviews

The banking institutions represent important stakeholders in the context of agribusiness, low-carbon emission agriculture policy, and to the process of agricultural innovation towards increasingly sustainable production with lower rates of carbon emissions. Banking institutions would need to be heard in this field survey. Thus, there was a semi-structured interview with open questions about the opinion of the members of the most important financial institution that operates the agricultural credits in Mato Grosso, especially in the north of the State.

The questions focused on: what is the level of demand for the ABC Plan by farmers? What level of consolidation of the ABC Plan in the state of Mato Grosso and especially in the north of the state? Would it be possible to compare the ABC Plan with other agricultural credits offered by the bank (advantages and disadvantages)? What are the problems and challenges in the Plan that could be improved? And, finally, what they could suggest for improving the ABC Plan and their sustainable technologies dissemination?

The banking institutions answered:

- The ABC Plan could be focused much more on the livestock. **T**his point of view refers to the fact that livestock farming is a harmful practice in the environment. The crop farmers are the ones that adopt more sustainable practices such as integrated systems, no-till planting and the use of inoculants for biological nitrogen fixation. Although some crop farmers do not adopt the ABC Plan credits, they have to move from the conventional to sustainable practices to generate more productivity, lower production costs, and more profitability, as well as being more beneficial to the environment. Cattle farmers, on the other hand, are the most resistant to changing archaic, environmentally degrading and low profitability practices;

- Despite being consolidated in Mato Grosso, the ABC Plan is still far below its potential for expansion and adoption. It needs more information to the user public and society, and there should be more work to raise awareness and mobilization of the rural producer and rural technical assistance.

- It is an important comment which means that ABC Plan and its set of technologies can be expanded and it requires a wider publicity plan and strategy to multiply its technical content and create easier financial mechanisms for attracting more producers, beyond the previous discussion about the need of stakeholders' groups be closer and more integrated.

- They suggest that could have a better preparation of the private technical assistance workers to elaborate the projects for capturing agricultural credits. They said that could have more training, with better structured and practical coaching, and with follow up the process, by monitoring and evaluating the trained people. In general, companies in the region usually have few technicians (on average 3) to attend to many farms, which leave them overwhelmed and difficult to assist the owners in the elaboration of good projects.

Analysis: It is necessary to expand the network of sustainable technology multipliers, integrating a greater number of public and private extension agents.

- They also suggest that the Pronaf (National Program for the Financing of Family Farming) should incorporate the ABC Plan to insert their principle, concepts, and technologies for familial farmers.

Interviews with Representative Members of the Productive Sector (medium and large farmers)

The following is summarized members of the representative organizations of the productive sector opinions, both nationally and in the state of Mato Grosso:

- They think that the credit interest for the ABC Plan is still very high, that the bureaucracy is great to access them. For them, adopting the technologies of the ABC Plan has a greater challenge for the livestock farmer than for the farmer. Reclaiming pasture is expensive and would require cheaper solutions or more convincing ways to mobilize livestock farmer. Concerning the technologies for the implantation of the productive systems proposed by the ABC Plan, there are no problems, and the solutions generated by Embrapa are very positive, including varieties of pasture, genetic improvement for cattle and even grains, although the latter is mostly bought from private companies.

- The launch of a new cultivar does not guarantee that the producer will buy if there is no concrete proof of the advantages and profitability of what he has already adopted. The agronomic part of Embrapa has been positive, but there is still a very large gap in the part of economic studies, viability and profitability, which leaves the producer often insecure about adopting some research solutions.

- It is necessary for the government to seek solutions to improve logistical infrastructure and access to agricultural inputs as a way to lower production costs. On the contrary, it is still cheaper to advance in the forest than to recover degraded areas or soils with low fertility.

- The reality has proven that when a large producer tests and adopts a technology, this experience serves as a reference for the medium and small producer also to adopt. It is worth mentioning that, in the state of Mato Grosso, the technical assistance and rural extension of the state government is only meeting the small producer. The medium one, as it does not have the same capacity as the big producer, ends up being without technical assistance and this causes serious losses in production, productivity in not adopting new technologies, generating low profitability and impoverishment of them.

- One hundred ninety-three thousand farmers and 90 rural unions are affiliated to the Federation of Agriculture and Livestock of the State of Mato Grosso, and indirectly to the National Confederation of Agriculture and Livestock. It is estimated that 100% of them adopt the no-tillage system and use inoculant for the biological nitrogen fixation, with that avoid the use of chemical nitrogen fertilizers, which is good for reducing negative impacts on the environment, especially by improving soil biology, as well as reducing costs and increasing profitability. More than 1,500,000 ha in State of Mato Grosso are used for integrated systems especially crop-livestock and in a lower quantity the forest-livestock system or crop-forest system.
- They suggest that one should think of simpler financing mechanisms to encourage the producer to expand access to ABC's credit. They said that irrigation must be included in the ABC Plan because climate changes have substantially affected rainfall, especially for the producers located in regions that are more sensitive to water stress. It recommends that the government implement policies to improve logistics and alternatives to make agricultural inputs cheaper.

Conclusion of the Field Experience

It was possible to observe, collect data and reach several conclusions during the field experience, which generated a series of important inferences that we can classify them as by-products of the work, but which cannot be dissected here, at risk of escaping the context of the thesis , however, all these results could be used in future research.

Beyond analysis, inferences and conclusions previously considered, other positive aspects were identified in the field experience:

- Database and information were enlarged after partners information collection to enrich impact analysis referred to agricultural technologies and low carbon emission public policy. This result let us confirm the importance of some adopted survey tools to achieve better data reliability and stakeholders 'opinions, at the same time, to observe fragilities of the other tools (with special consideration for semi-structured interview script, which means, the need to apply this tools by adopting informal meetings);

- The experience of interview process and interaction with local producers have generated learning toward interview script and strategies adjustment for improving the process of information capture from farmers (they are normally sensitive to inform on their incomes/profit and about environmental problems related to its production systems and farms);

- Data collected related to GPS coordinates points for structuring image modeling by using geotechnologies denotes that it represents an important option for collecting field data to characterize space-temporal territory used in agricultural systems supported by ABC Plan and other possible policies or innovation projects. This tool is also important to elaborate a platform capable of identifying areas of permanent preservation and legal reserve according to National Forest Code - Brazilian law that disciplines land use based on sustainable development principles - Law 12 651 / 2012 – (Casa Civil/PR, 2012)[9], well applicable for Brazil's country reality. In spite of this, it is essential to carry out on-site visits to confirm data collected by images;

- Absorption of knowledge from the local reality of big and medium producers by observing the local environment and from dialogue with them. It proves the need for on-site visits, as well as the adoption of behavioral strategies (requiring skill)

[9] Reference: Casa Civil – Presidencia da Republica / PR. (2012). Lei nº 12.651, de 25 de maio de 2012 – Dispoe sobre a protecao da vegetação nativa. Available at: www.planalto.gov.br/CCIVIL_03/_Ato2011-2014/Lei/L12651.htm.

that promote a climate of trust and tranquility between interviewers and stakeholders.

Annex 2: Images of Farms Visited during Field Experience

Image 1 shows more precisely the six municipalities in the north of the state of Mato Grosso where are located visited and analyzed farms. It is an area framed in the Amazon Bioma, but with fragments of Savannah which could be characterized as a transition zone between the Amazon and Cerrado biomes. But, it is visible the predominance of forest in this region.

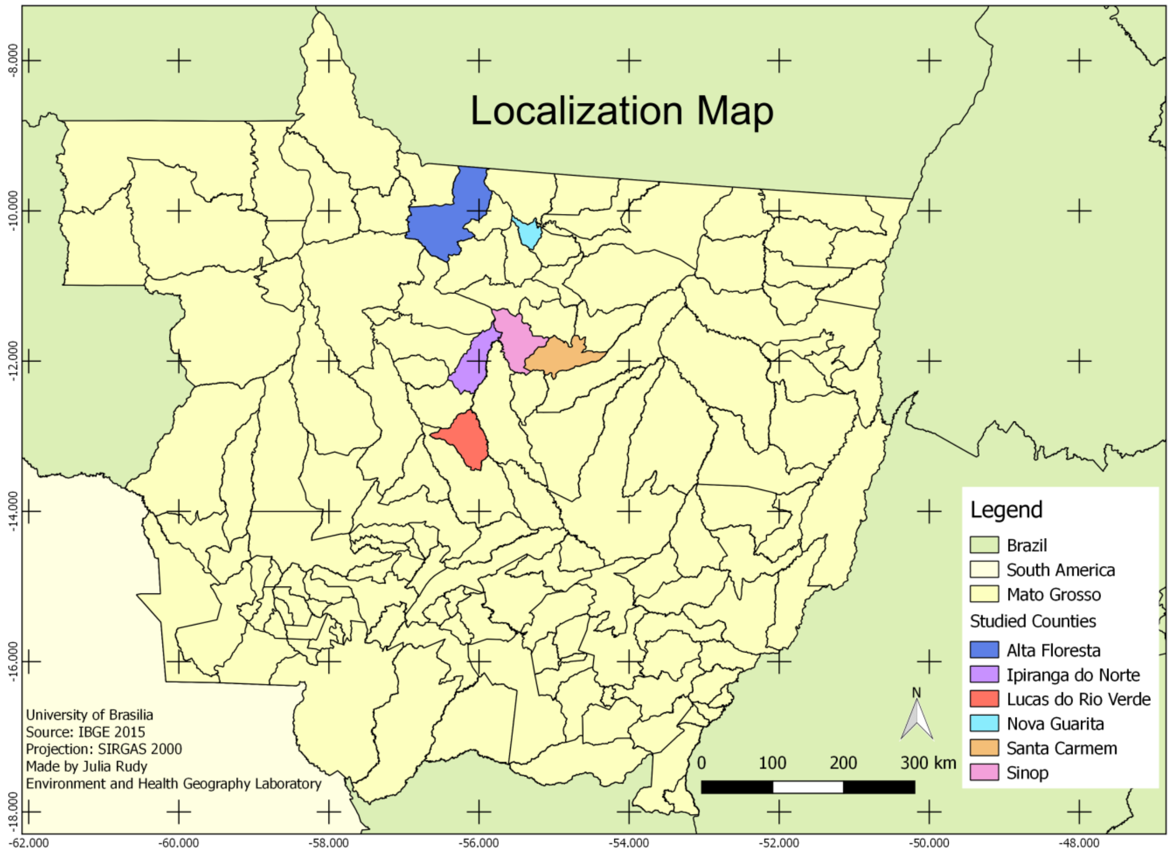


Image 1. Study Area, North of the Mato Grosso
Made by Lagas, Geography Dept, University of Brasilia, 2019. Source: Sistema do Cadastro Ambiental Rural – CAR, 2019.

Image 2, below, demonstrates a specific farm in the Ipiranga do Norte municipality.

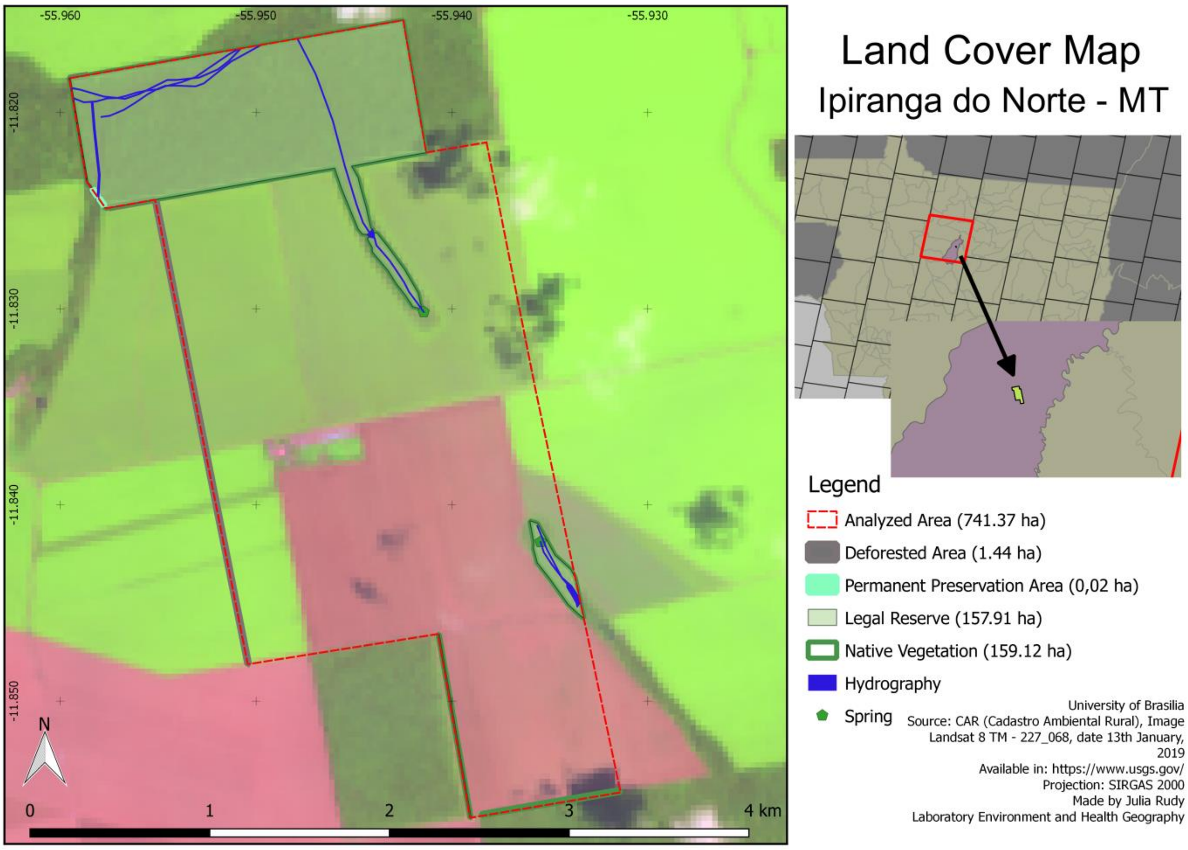


Image 2. Farm “1"
Made by Lagas, Geography Dept, University of Brasilia, 2019. Source: Sistema do Cadastro Ambiental Rural – CAR, 2019.

The municipality of Ipiranga do Norte is within a biome transition zone between Amazonia and Cerrado. In these cases, according to current legislation, the Legal Reserve should be 80% of the farm, but if the owner complied with the previous legislation (MP No. 2.166-67, dated August 24, 2001 that established the legal reserve at 50% of property), article 68 of the current law exempts these farms from promoting forest restoration, compensation or forest regeneration.

The farm referred to in Image 2 above, located in the municipality of Ipiranga do Norte, did not adopt the technological solutions of the ABC Plan. It is important to point out that the farm that adopts the solutions required by the ABC Plan must necessarily comply with the Forest Code, a basic condition for having its planting project approved by the competent bodies to obtain the bank's financing.

Naturally, all properties must comply with the law, but the infrastructure limitations of the government's environmental inspection bodies make it difficult to monitor and verify all Amazonian farms and transition areas between this biome and the Cerrado. Also, there is a transition period for farms to adapt to the new legislation. Thus, the federal government sought to stimulate the adoption of the new law with a credit incentive with lower interest rates for those who opt for the ABC Plan and the technologies inserted in this policy.

It is observed in Image 2 that the said farm is not complying with what determines the legislation, in what concerns the areas of permanent preservation and legal reserve. The property has 741.37 hectares. Thus, according to legislation applied to this region, it should have 50% of the area as a legal reserve, which can insert the permanent preservation area, which means approximately 370 hectares of reserves. When analyzing the image above, it is verified that the farm has only 157.93 hectares of reserves, that is, less than half of what the legislation demands.

Image 3, below, shows a farm that adopts ABC Plan, in the same municipality as the previous farm (Ipiranga do Norte). These two farms have a comparative effect concerning compliance with current environmental legislation (Brazilian Forest Code).

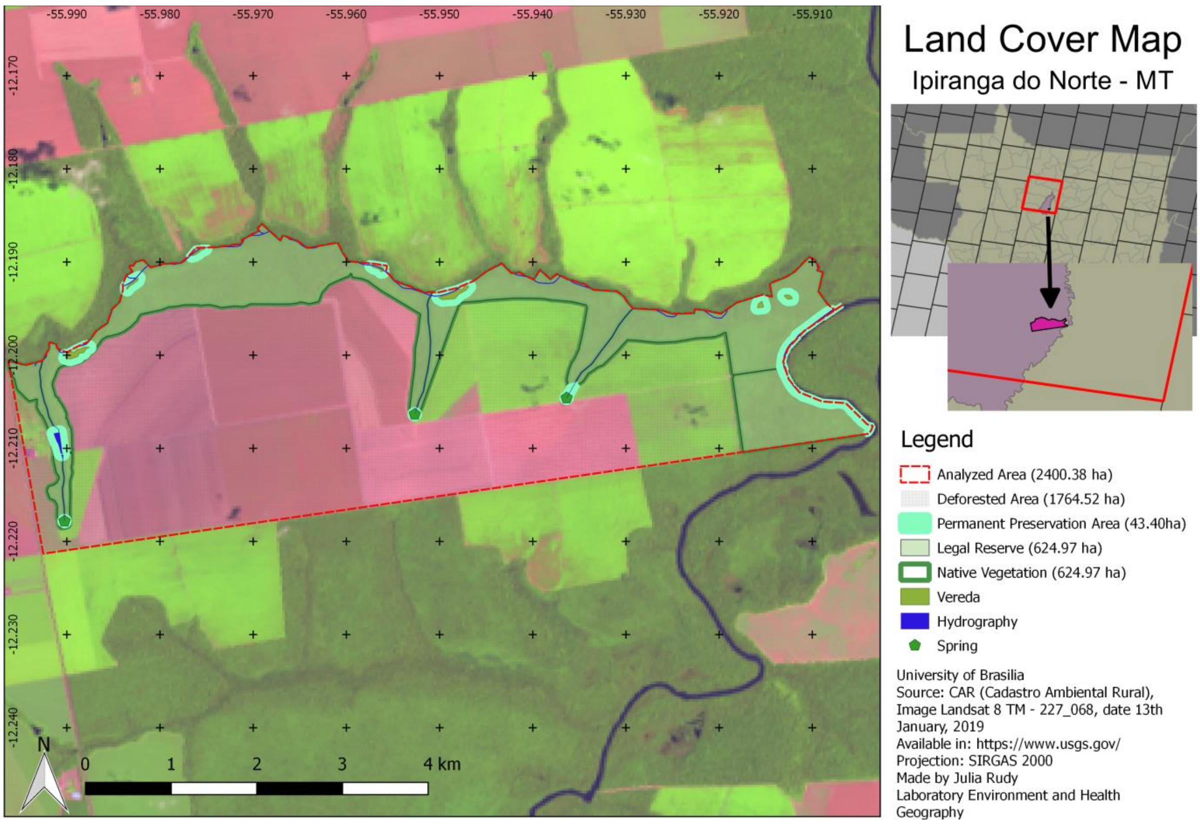


Image 3. Farm "2"
Made by Lagas, Geography Dept, University of Brasilia, 2019. Source: Sistema do Cadastro Ambiental Rural – CAR, 2019.

When analyzing image 3, above, it is verified that this farm, which adopts the technological solutions proposed by the ABC Plan, has approximately 2,400 hectares, that is, it should have 1,200 hectares of reserves. The farm meets only 55% of what the law requires (approximately 668 hectares). It is slightly better than the farm mentioned in the previous image, but still far from meeting 100% of what the Forest Code advocates this region. This comparative analysis is far from ideal, in terms of sampling, however, it was only done for illustration and to demonstrate the importance of geotechnologies as a low-cost tool, with a relatively short time (positive cost/benefit) if compared with visits in the field. Although, a local visit is essential for checking some analyzed images, by sampling.

Annex 3: Interview Script Templates

(Roteiro-Base Semi-Estruturado de Entrevista – Destinado a Stakeholders)

I) Identificação

1. Nome:
2. Autônomo? ( ) Sim ( ) Não – A que organização pertence: ....
3. Há quanto tempo atua na área?...............anos
4. Sua cidade-base:....................................
5. Município(s) onde possui fazenda..
6. Tipo de fazenda que possui: ( ) grande ( ) média ( ) pequena
7. Reside na fazenda? ( ) Sim ( ) Não...............................
8. Tipo de agricultura ou pecuária que possui:.......

II) Dados Técnicos

1. Que tipos de sistemas produtivos adota?
2. Recebe assistência técnica? ( ) Privada ( ) Pública/Oficial - De que maneira se processa essa assistência técnica? (visita em campo, telefone, internet/e-mails, videoconferências tipo Skype...).
3. Como você avalia a assistência técnica que recebe?
4. Como as informações sobre tecnologias e práticas agropecuárias chegam até você (assistência técnica, treinamentos, acesso a folhetos, e-mails ou sites, dias de campo...)?
5. Como você analisa vê a Embrapa? Que tipo de benefício você recebe dela?
6. Você recebe tecnologias ou informações científicas de outras instituições de pesquisa que não seja a Embrapa? Se sim, quais instituições e como é a relação com elas?
7. Que sugestões de melhoria você daria para melhorar a relação com a Embrapa?
8. Como você avalia sua relação com as instituições que financiam a produção (bancos).
9. Que outros comentários gostaria de fazer sobre pesquisa e extensão.
10. Gostaria de comentar algo mais?

(Roteiro-Base Semi-Estruturado de Entrevista)

Destinado a Técnicos de Assistência Técnica Agrícola)

III) Identificação

1. Nome:
2. É funcionário: (   ) Público Estadual - ....   (   ) Público Municipal - ....
   (   ) Privado - ....
3. Há quanto tempo atua na área?...............anos
4. Sua cidade-base:....................................
5. Área onde atua (municípios):..
6. Tipo de fazenda que atende: (   ) grande   (   ) média   (   ) pequena – familiar
7. A quantas fazendas dá assistência?................................
8. Frequência de visitas a fazendas: (   ) mais de uma vez por semana
9. (   ) uma vez por semana   (   ) mais de uma vez por mês (   ) uma vez por mês
   (   ) uma vez a cada três meses   (   ) outras (descrever):............................

IV) Dados Técnicos

1. Que tipos de sistemas produtivos você fornece assistência técnica?
2. Em que culturas agrícolas e/ou tipos de pecuária você fornece assistência?
3. De que maneira se processa a assistência técnica? (visita em campo, telefone, internet/e-mails, videoconferências tipo Skype...)
4. Como as informações sobre tecnologias e práticas agropecuárias chegam até você (treinamentos, divulgação em folhetos, divulgação em e-mails ou sites, dias de campo...)?
5. Como você analisa a relação entre você / sua instituição e a Embrapa?
6. Você recebe tecnologias ou informações científicas de outras instituições de pesquisa que não seja a Embrapa? Se sim, quais instituições e como é a relação com elas?
7. Que sugestões de melhoria você daria para melhorar a relação com a Embrapa?

Annex 4: Further Operational Information of IIAMS

This annex contains a series of byproducts and details of the Innovation Impact Assessment Management System – IIAMS. As the work of deepening and dissecting the understanding as well as the description of the Model was advancing, a series of important specificities and by-products that could be explored in its implementation phase was observed. This annex is divided into three parts: 1. Sustainability Formula, 2. Sustainability Components Descriptors, and 3. Instruments (Tools) and Products of IIAMS.

1. <u>Sustainability Formula</u>

All indicators will adopt a measurement scale varying from -3, on the most negative impact, to +3, on the most positive impact, being "0" for cases of unchanging, the case of neutral impacts. for the purpose of facilitating reading and understanding by some actors, especially society in general, it is possible to convert these values into general concepts, for instance: -3 = extremely negative; -2 = very negative; -1 negative; 0 = neutral, unchanging or no significant change; + 1 = positive; + 2 = very positive; + 3 = extremely positive.

Figure 1, below, demonstrates directly the conversion correspondence of each impact indicator.

-3	**-2**	**-1**	**0**	**+1**	**+2**	**+3**
Extremely Negative	**Very Negative**	**Negative**	**Unchanging (Neutral)**	**Positive**	**Very Positive**	**Extremely Positive**

$$\frac{\text{[Economic] + [Political/Policy] + [Social] + [Environmental] Dimension}}{\text{Sustainability Function (SF)}} = \boxed{\text{Sustainability Balance}}$$

Figure 1. Sustainability Scale for Measuring IIAMS Indicators

Figure 1, above, also displays the Sustainability Balance, which represents the sustainability indicator of an innovation's solution generated by the research organization. It is the weighted average of the respective indicators. SF is the sustainability function, represented by the sum of the weight of each dimension.

During the practical process of evaluation, it will be found some indicators, especially such as those related to the economic, political and social dimensions, with qualitative or even quantitative characteristics, however, with different measurements and difficult to fit into the scale mentioned above.

Meantime, it is suggested that each evaluation team constructs a creative way of converting their results by inserting them into this scale grid, which will facilitate the standardization of reading and a consolidated evaluation at the end. This consolidation will facilitate the reach the **Sustainability Balance as a measurable indicator for each technological solution**.

Based on Figure 1, it can be read of the following formula:

SBi = (Ed) 3 + (Sd) 2 + (Pd) 1 + (Ed) 1/7, where SBI represents the level (adopting the same scale grade, from -3 to +3) of Sustainability of a certain innovation or Technological Solution adopted by the productive sector. Ed represents the environmental dimension multiplied by weight 3; Sd is the social dimension multiplied by weight 2; Pd is the political dimension, multiplied by weight 1; Ed is the economic dimension, multiplied by weight 1. This sum will be divided by 7, obtaining the weighted average which represents the level of sustainability of an innovation's solution.

This formula has its original theoretical reference on the Proto-Model and main figure of the IIAMS, according to the main text of this thesis. It reinforces the scale of values among the four dimensions that shape the concept of sustainability under a cross-sectional vision. It is understood, therefore, that the environmental dimension is the most important and so was left with the weight 3, the social dimension with weight 2 comes next, and finally, the political and economic dimensions with weight 1, respectively.

It is understood here that if the environment is adversely affected, there will be direct or indirect reflexes for the society that is inserted in the larger environment. It is the society that builds political and economic frameworks. In this sense, society (through its institutions) must establish public policies and a structural and operating framework of the economy in such a way as to provide values and conditions so that there is a healthy social field and immersed in a dignified and responsible pattern of quality of life.

If the environment is destroyed, it destroys society and its economy, because they depend on a healthy environment to continue interacting, extracting and sustainably managing the natural resources, and thus, maintaining in a state of resilience the environment that sustains them through their components: air/atmosphere, sunlight, soil, minerals, water, biodiversity, and forest resources.

The Ambitec-Agro methodology (driven by Embrapa) has more than a hundred indicators, with a detailed measurement spectrum, and by linking it with data input to IIAMS it can reinforce environmental and social database from each evaluated technological solution. But IIAMS in its specific framework intends to restrict itself to only some points considered the most relevant ones, especially taking into account the UN sustainable development goals and national environmental legislation, and a set of most relevant added information to society.

A great part of Ambitec and Social Balance indicators of the Embrapa's impact assessment methodology can be absorbed by IIAMS methodology, however IIAMS has a summarized structure of indicators as a simplified way for evaluation teams. IIAMS also seeks to facilitate reading by stakeholders due to its compacted data and information, and focusing on essential points (producing a report format accessible to the citizen, with few words and reduced technical explications).

In the present day, time becomes more and more scarce, within a relative analysis between time patterns versus broad professional and other commitments. There are cases, especially in public organizations, where certain tasks peripheral to the innovation mainstream, and excessive reporting to supervisory and external audit institutions, affect research productivity and may generate negative impacts on final technological solutions.

Transparency and accountability are essential in an organization, even more so if it is a public institution, however, it is necessary to seek assertive, simplified ways and with information that is essential for stakeholders, the supreme auditing institutions and society. It is clear that technical details will be fundamental for research and innovation teams to make adjustments in their processes, but these detailed reports will be valid for the actors most directly involved with the research.

Three important aspects must be taken into account:

- First, in the ***ex-ante*** **assessment**, all impact forecasts will function as future scenarios (targets for future impacts to be pursued), and evaluation team must ask: **what impacts are there today with current technologies and what impacts are expected with the future solution?** In addition, the exercise of future scenarios should act as a risk prevention mechanism in the case of solutions aimed at eliminating or reducing risks (such as pests and diseases, invasive species, etc.);

- The second one refers to the ***ex-post* impacts**, and, in these cases, **a comparative analysis should be made between the existing impacts with the previous technological solution and with the new solution**. This comparison will help the assessment team to obtain a referential base regarding reached advances on impacts as well as to make adjustments in future policies, projects and processes; and
- the third refers to the need to be attentive so that the **impact assessment does not consider cumulative measures, which can mask the result, regardless of the sustainability dimension evaluated**.

For example, when testing a productive and rustic cultivar that requires low pesticide use, groundwater from that farm may be contaminated by the intensive use of pesticides from another production system on a plot of land neighboring the one being tested for the new solution. The connections of rivers and groundwater currents, depending on the region, can create extensive capillarities and systemic interactions. Thus, such contamination may mask the final result of the impact analysis of the studied area.

Another cumulative and masking effect of indicators evaluated may be the existence of tenuous boundaries between two technologies that work together, so that the economic outcome of a solution under evaluation may be absorbing reflections from another already underway. Thus, these technological contributions must be adequately separated during the analysis.

On the other hand, it must pay attention to the fact that many technological solutions generate repetitive impacts for a long time. Many impact assessment criteria of research organizations and evaluating institutions must be rethought, and this indicator must be considered and positively be added since it shows how a single solution can compensate for the efforts of other researches that have not been so successful (and this is an inherent risk of the research). The positive impacts of a solution can compensate for many years the volume of resources applied to other research fronts.

A clear example of this is the experience of Embrapa with the Biological Fixation of Nitrogen, developed in the 1970s and that generated very significant environmental, social and economic impacts 20 years after its first field tests, and from now on the tendency is that this solution will generate even more positive impacts. For example, ten years ago Brazil stopped importing 2 billion dollars of nitrogen fertilizer for soy production. Currently this figure reaches 13 billion dollars and the tendency is to expand, especially with the result of research aimed at applying this solution in other crops, in addition to legumes (Embrapa, 2018)[10].

This negative or positive, and ethic or unethical experience of measurements should be well defined and separated, and it is important to clarify it for supreme auditing institutions, supervision organizations, stakeholders and users of the research organization.

Indeed, it is not unethical to insert repetitive indicators, if positive or negative, related to a specific solution, along the years of impacts. It demonstrates effectiveness or not from one technological solution effort and its long-term effects. An ideal future target of impacts of a research organization would be solutions generated with repetitive positive impacts over a long time (economic, social, political and environmental).

2. Sustainability Components Descriptors

The components descriptors of sustainability of the four dimensions (environmental, social, political and economic) must follow the criteria below, and each one should be checked whether the technological solution under evaluation has relation to the natural resource or aspect under analysis (whether or not the case applies):

a) The Environmental Dimension and its Descriptors Components

The IIAMS Model has a set of environmental, social, political and economic components on which will be applied sustainability indicators, which can be seen in Figure 13, on page 141 of the thesis main text, that they are detailed below (henceforth when

[10] Empresa Brasileira de Pesquisa Agropecuária – Embrapa. (2018).Organization's main site, available at: www.embrapa.br, accessed 03/18/2018.

referring to the term "zones", it is important to consider the need to see figure 13 of the main text of the thesis):

- **Soil** - This component will measure two indicators: the **soil quality and the conservation level (sub-indicators related to specific aspects analyzed in each case, quality and conservation, must be summarized/reduced towards only these two indicators)**. If applicable, the impact of this solution on **soil quality** and **conservation level** will be assessed. The evaluation process will occur exclusively in local, it means, inside the farm or propriety.

On **soil quality evaluation**: the data collection will be restricted to the Zone 1 and it will analyze the improvement grade, unchanging or worsening of the physical and chemical quality of the soil. It can be applied to *ex-ante* and necessarily to *ex-post* evaluation. After making soil analysis on its **physical and chemical quality**, the assessment team will make the average calculation that will compose the general report (both analyses will be summarized in just one **soil quality indicator**), while maintaining as attached information as detailed evaluation on each aspect as technical feedback for consultation of innovation team related to the solution.

Soil Quality by regarding the soil physical structure: it will be considered two parameters: the index composition of **organic matter and pH**. The organic matter content is important to indicate the degree of soil texture, which influences its physical, chemical and biological quality. The organic matter content has varying degrees of proportionality, varying according to the type of soil, having ideal reference values of 15g / dm³ for sandy soils, between 16 and 30 g / dm³ for medium texture of soils and 31 to 60g / dm³ for clay soils (Landon, JR, 1991[11]; Camargo et al., 2009[12]).

These references, however, are parameters that can be adjusted by each research team specializing in soils according to the climate, type of crop, cultivars and technologies adopted, which may imply proper soil organic matter demand characteristics. Given this, these indicator references may be appropriate to local particularities. Thus, **important is to**

[11] Landon, J.R. (1991). Booker Tropical Soil Manual: a handbook for soil survey and agricultural land evaluation in the tropics and subtropics. Routledge, Taylor & Francis Group, New York. ISBN 13:978-0-582-00557-0.

[12] Camargo, O.A.; Moniz, A.C.; Jorge J.A.; Valadares, J.M.A.S. (2009). Métodos de Análise Química, Mineralógica e Física de Solos. Boletim 106, 77pp, Instituto Agronômico de Campinas – IAC.

evaluate the impact of the technological solution under the final indicator of quality in the organic matter if, positive, negative or unchanging.

Soil Quality by regarding the **chemical soil composition:** the parameter of measurement will be the **pH**, varying between 5 and 7, as a minimum and maximum acceptable respectively, according to the type of culture (Landon, 1991).

For both aspects, in case of adopting the Ambitec-Agro method, make the conversion to this scale, if it is the case.

Regarding soil conservation: this indicator adopts as parameter the degree of soil preservation versus erosive processes or soil losses. It can be applied to the *ex-ante* and necessarily to *ex-post* evaluation. This measurement must occur through in situ observation (inside the Zone 1), by identifying the soil protection level (usually indicated by the volume of organic matter or mulch on the soil), comparing the previous technology and after innovation adoption.

It is important to observe the parameters for measuring which will face influence from local geomorphology characteristics and soil sustainable management, so there are relativity factors to be considered in this analysis. For example, a site with a high, medium, or low slope of land will relatively affect the evaluation grade of greater or lesser erosive impact and consequent loss of soil, according to its greater or less protection. Add to this, protected systems that adopt conservationist practices such as no-tillage and use of contour lines or terraces, as each situation demands.

- **Water -** The term water here has a broad spectrum of understanding, since it contemplates water resources in the general sense, ranging from the degree of sustainability of use to the impacts on groundwater and hydrographical basins. This indicator is divided into three smaller measures (sub-indicators): **the underground water quality, the water sustainable use, and impacts on the local-regional hydrographic basin.**

All these water indicators can be applied only in the *ex-post* evaluation, because they deal with complex effects and difficult predictability. Water due to its physical and dispersion characteristics is subject to the influence of several factors, including several that are not related to the technology being evaluated. Thus, it is important to be aware that the influence of other factors or elements does not interfere in the analysis of impacts related to specific technological solutions.

The underground water quality has to be assessed only locally or inside farm/propriety (Zone 1) and must identify the presence or not of chemical residues of pesticides or herbicides at levels considered toxic for human beings or animals, as well as the presence of total and fecal coliforms. This identification can be realized through the collection of water from wells that access the water table or any water underground accumulation or flow.

The Water Sustainable Use means the conservation level water. It has to be assessed regarding the use in production systems, which means the optimization grade of using, that is, to valorization level the water use by considering the lesser water expenditure possible without productivity prejudice (the data collection will be restricted inside the farm or propriety – Zone 1).

The **impacts** evaluation on **local-regional hydrographic basins**, means to analyze impacts from certain technological solution on the water springs, rivers or any hydrographic basin located into municipality (**local basins**, that is, framed with the scope of micro-basin systems – must consider Zone 2 for data collection).

This analysis will be extended to hydrographic **basin systems** into a **regional or state** level (Zone 3).

- **Landscape -** Indicators of the landscape component will be limited to the degree of impact on areas of **riparian forests**, ie if they are under a state of maximum preservation (+3) or total degradation (-3), or in an unchanged state ("0"), before versus after the new technological solution. In the case of the Brazilian territory, the law that establishes the forest code will be used as a parameter, regarding the Permanent Preservation Areas. It can be adopted for *ex-ante* evaluation and necessarily for *ex-post* evaluation.

As a first approximation exercise of evaluation of the natural or modified/anthropized landscape, one can use geotechnologies, but it is recommendable in a second moment to make on-site observations, with the effect of the satellite image validation.

This component will be restricted to inside farm/propriety and municipality area evaluation (Zones 1 and 2). The idea here is to extend the analysis of the natural or modified landscape (riparian forests) from one propriety to the municipality, has the purpose of establishing a minimum limit of analysis of zones that can create ecological corridors between these forests.

Beyond that, from a unitary sample farm under impact study to a bigger sample, providing a wider geographic space, by viewing the municipality where are located properties that adopted the technological solutions in impact analysis, confronting the reality with the environmental legislation referring these areas protection.

- **Waste Management -** This component will measure the waste management resulting from the production system (which has adopted a solution, *ex-post*, or that will adopt, *ex-ante,* thus must be used by both timing of evaluation). It is focusing on solid waste and liquid effluents.

This indicator should be applied in zones 1 and 2, that is, within the farm or property and the municipality, encompassing the management of solid waste and discards related to technological innovation under evaluation (including impacts resulted from products or production process affected by the new technology). A solution can promote the generation of waste that impacts the environment inside the producing property and can extrapolate it to the neighborhood and other areas of the municipality, which can generate varying levels of impact.

It will regard environmentally responsible handling and disposal of pesticide, herbicide and chemical fertilizer packaging. It must evaluate if all those packagings are collected responsibly, managed and packaged in a hermetically sealed manner to prevent intoxication of persons, animals or contamination of the environment (whether water, soil or gases emission, in case of burning it). In the case of technological solutions related to the industrial or service sector, also must be observed the disposal of other inorganic packages and the way the industrial and domestic sewage is collected, treated (or not) and dumped.

- **Productive System Diversification** - This component is to compensate for the fact that an analysis of the local native biodiversity is not included in IIAMS (which will not occur due to its complexity, both animal and vegetal). Thus, the methodology searches to adopt the strategy of analyzing the productive biodiversity degree, measured by the diversity of the productive system resulting from the technological solution proposed or adopted.

For example, the wide spectrum of crops diversity, integrated agriculture-livestock-forest systems, agroforestry systems in the succession species model and with a high diversity index in a simultaneous consortium, among other systems that adopt crop rotation and consortium. In this case, the maximum positive evaluation (+3) is a system with a high degree of diversity and species integration, and maximum negative (-3) purely monoculture systems, without the minimum rotation or consortium of crops. This component will be restricted to the farm/propriety analysis (Zone 1) and has to be used for *ex-ante* and *ex-post* evaluation.

- **Atmosphere** – This component is focused exclusively on carbon emissions to the atmosphere, more precisely, it seeks to assess the carbon balance resulting from the adoption of a given technological solution, by comparing it with previous one. It will be the only one environmental component to permeate all spatial scales: local (within the farm or property), municipal, state or regional, national and international (from Zone 1 up to the Zone 5).

This analysis through the various zones of spatial scales will allow having a concrete idea of the reflexes of the product that was used of a certain technological solution and its reflexes along one or more supply chains. In this component, a just *ex-post* evaluation will be made (*ex-ante* evaluation will not be applied in this case).

b) The Social Dimension and Descriptors of its Components

- **Job Creation** - This component will indicate the jobs number generated with the adoption of the new technological solution, making a comparative analysis with the use of the previous technology. This indicator analysis will be applied from zone 1 up to 5 one for data collection. It has to be adopted for *ex-ante* and *ex-post* evaluation.

The labor generation indicator (which it is supposed to be added to the generation of respective income) can be inserted as an economic or social component. In this methodology it was decided to consider it as a social impact, result of economic factors. Observing Figure 13 (page 141), it can be verified that products or services resulting from an innovative or incremental solution can cross several spatial scales through several supply chains, leaving the local level, can reach the state and national and even reach the marketplace of the international / world.

To establish an acceptable measuring parameter, it is possible to carry out a scenario exercise by fixing limits to more and less and to consider its reflex about acceptable efficiency for working with the use of the new technological solution under the impact study. For example, if it resulted in the generation of two new jobs, one should carry out a scenario exercise that would be as acceptable as possible so as not to have a very negative impact on the producer profitability. This framework would provide limits to fit the scale ranging from +3 to -3 and then be classified as an extremely positive or extremely negative impact.

- **Cohesion and Social Inclusion** – Well emphasized by CSIRO (2017)[13] methodology, this component is related to the social cohesion and social inclusion indexes generated by the new technological solution, compared to the previous solution. It has to be adopted for *ex-ante* and *ex-post* evaluation.

It will be measured in zones 1, 2, 3 and 4, as a way for stimulating cooperatives and other associative movements to strengthen interrelationship among actual and potential groups of peers and partners along the supply chains. It is natural that cohesion and inclusion have a strong emphasis on local efforts, but understanding that supply chains denote a systemic logic of interaction and inter-influence by a social and market perspective.

For Durkheim (Mauss, 1969)[14], Social Cohesion is related to a state of collective consciousness and existence by which individuals remain united, integrated into a social group, or, in a cohesive integration of the social group to which they belong, implies creating the spirit of solidarity, despite people are inserted into a complex social ambiance.

Social cohesion can be understood as a process of developing interpersonal relationships, which stimulates and promotes engagement in interactive and associative movements. They are also organizational innovation, initiatives, and processes to strengthen

---

[13] Commonwealth Scientific and Industrial Research Organisation – CSIRO. (2017). The Value of CSIRO. An Estimate of the Impact and Value of CSIRO's Portfolio of Activities, conducted by Acil Allen Consulting. Available at: www.csiro.au.

[14] Mauss, Marcel. (1969). "La cohésion sociale dans les sociétés polysegmentaires" [1931], pp. 11–26 in Marcel Mauss. *Oeuvres*. Vol. III: *Cohésion sociale et divisions de la sociologie*. Paris: Éd. de Minuit.

agricultural, industrial, commercial, and credit cooperatives, as well as other models of association.

It can be also considered associations or movements that promote larger empowerment of producers, their families and firm employees (including their families).

Processes that promote greater integration among producers and members of the supply chains, implementation of productive arrangements. Also included social and productive inclusion resulted from the impact of the new technological solution adoption. This component intends to stimulate the local development and so, to stimulate innovations that promoting local social and economic development, by respecting the environment.

Social technologies are well applicable to this component, as well as innovations framed within a systemic, constructivist, transdisciplinary and holistic approach (as recommended by IIAMS), which promote greater integration among the actors involved in an innovation process. The impacts are reflected not only between the actors directly involved in the development of innovation, but also the producers or users of innovation, in their technology transfer phase and during the adoption follow-up in the field.

- **Health, Nutrition and Food Safety** - These three aspects are closely related since food safety must ensure good nutrition, which in turn is one of the attributes for good health. A new technological solution, if compared to a previous solution, impacts may be positive, negative or unchanging, regarding producer and his family/farm and firm employees health, and in that scope can be inserted the issues of food safety and nutrition by chain effect (when the evaluation occurs within of the farm or property that adopts the solution – Zone 1).

This set of indicators must be applied for the *ex-ante* and *ex-post* evaluation process.

On the other hand, when analyzing other spatial scales, such as the municipal, state and national levels (zones 2, 3 and 4), the aim is to focus on the indirect beneficiaries of the technological solution, it means, the solution impact on the food safety, nutrition, and health of the final beneficiaries that consumed the product affected by the new technological solution.

- **Local-Regional Culture** - This component refers to the adoption of solutions that respect local or regional cultures, or that promote and strengthen them, as long as this valuation is reflected positively in economic gains and socio-environmental responsibility. If the technological solution was the result of an innovation that had the collaboration of traditional knowledge or the experience of productive sector members, this solution has high cultural-local worth.

If the solution negatively affects or destroys local cultural worths important to environmental conservation and culture, this solution will certainly have an extremely negative impact within this component. This indicator will be applied in the local (inside farm/propriety), municipal and state spatial scales (Zones 1, 2 and 3), and has to be applied for the *ex-ante* and *ex-post* evaluation process.

- **Education** – The application of this indicator measure will be limited to the local space (Zone 1), inside the farm or property, being restricted to the producer, his family and farm/firm employees. That is, compared to the previous solution, what degree of impact the innovation under analysis affects the education of the producer, his family, farm/firm employees and their families (positively, negatively or keep it unchanged). It must be applied for the *ex-ante* and *ex-post* evaluation process.

Education is understood as the whole learning process of the producer and his / her family/employees, both through formal education (at school access) and non-formal education (through training, field days, workshops, seminars or other forms of knowledge transfer). It also includes access to technical, managerial and quality of life information. It is important that access to information or absorption of knowledge must reflect in producer and his family/employees behavioral and attitudinal changes.

c) Policy/Political Dimension and Descriptors of its Components

- **Local Impact of Public Policies** - This indicator refers to policies formulated and implemented by the municipal, state or federal government and their respective impacts in the local area and municipality (zones 1 and 2). It must be applied for the *ex-ante* and *ex-post* evaluation process. One has to think about a specific or a set of public policies and their reflexes to the local economy, local social development, as well as to the balance and local environmental resilience (for the producer, his family and in his propriety, as well as to a set of producers in the municipality).

It includes all policies which the research organization has directly participated (with technological, organizational or political innovation) that promote sustainable development ("think global and act locally"), that is, any public policy that promotes economic and social development and conservation of the environment. Thus, the idea is to verify if political measures are actually generating effects in the practical world, in the field, in the "factory floor".

The impact evaluation of this component may have a valuable impact on the adjustment of public policies, especially if these were elaborated without a participatory process or public consultations with those who will be affected by them. It can be a policy which in this scope are inserted one or more technological solutions from the research organization (in this case, the policy and the technology transfer are strictly associated, thus, the policy design have to consider strategies for innovation effectiveness).

For example, there is a public policy within the Brazilian federal government aimed at encouraging low-carbon emission agriculture - ABC Plan (Mapa, 2018)[15]. How is this policy reach to the farmers? What impacts is it actually generating in the production systems? How can it be improved? What aspects can be improved in the alignment between the agents of the federal government and those who represent the states and municipalities?

This component may allow an assessment of the policy pathway, or what Political Science calls the policy cycle, identifying barriers or opportunities to improve its process performance, and impacts.

- **Alignment among the Stages of the Impact Pathway** (Strategic Plan, Innovation Projects, Outputs, Outcomes and Impacts) – This indicator has characteristics of institutional politics of research and innovation as a process. It seeks to measure the level of alignment of the institutional policy successive stages expressed by its Strategic Plan, priorities, the portfolio of projects and organizational processes, a specific innovation project, its output, its outcome, and respective impacts.

---

[15] Ministerio da Agricultura, Pecuaria e Abastecimento – Mapa. (2018). Assuntos: Sustentabilidade, Plano ABC. Institutional main site, available at: www.agricultura.gov.br.

Adopting as a starting point a specific technological solution, this indicator will be applied in the *ex-post* evaluation. It will verify the alignment grade between the impacts achieved and the previous stages. So, will be evaluated the efficiency between what was planned (*ex-ante* evaluation, step-by-step) versus its results and impact targets, identifying the non-aligned points and proposing improvement solutions for future projects.

Thus, it verifies the degree of alignment between *ex-ante* (what was planned) and *ex-post* impacts (what actually occurred in the economy, in the social and ecological environment), about a technological solution.

This measure will have a strong influence on the behavioral posture of organizational leaders, intermediary managers and project and team leaders, ie, it will measure the manager's political posture and the impacts of this managerial posture to the project's results, until the final phase of impacts. Often the failure of a project and its results may be related to the inability to manage people and processes, which requires the capacity of motivation and engagement of the teams of internal and external actors.

This indicator will evaluate the process of innovation along its impact pathway, focusing on behavioral aspects (as related to the literature review and recommended an ideal innovation system and impact evaluation process). Leadership attitude based on Agile Leadership, transdisciplinary, holistic and constructivist approaches will be checked in this indicator.

According to previously mentioned behavioral and leadership approaches, an innovation may generate negative impacts not necessarily due to its scientific content, but owing to inappropriate management way of driving organizational policies or construct and lead innovation project by managerial unskill, as well as by because of ineffectiveness during the technology transfer.

This evaluation should occur only about the producer and the productive chains related to what farm/firm produces, given the technological solution that supported or enabled its production system. This component represents the evaluation of the management process of the impact assessment, following the pathway of innovation from conception to final impacts.

The previous item measures the degree of alignment between public policies and actions in the field. This item measures the degree of alignment between the policies of the research organization, the innovation process and the impact of the solution, that is, it verifies the level of impact of the institutional policy of research and innovation inserted in a sample, in this case, an innovation.

After evaluating several innovations, one should sum and make an average of all them to have a view of the average impact of the institutional policy distributed among all outcomes under impact assessment. The final product will be the tuning grade between the institutional policy of research and innovation impacts.

- **National Policies Compliance Level** - This indicator should be applied in *ex-ante* and *ex-post* evaluations in Zone 4 (national geographic space), and will measure the relationship between the impact of a given technological innovation and public policies in the areas of labor, citizenship and social respect, environmental, economic, among others.

When initiating an innovation process it is necessary to observe the current legal precepts, as well as the public policies in progress or that affect or can be affected by the technological product. Thus, when generating an innovation it is necessary to verify if it is complying with laws and norms, and if it is in tune with policies that demand or that with them can interact, in the social, economic and environmental fields.

The cycle of policies, as well as the process of generating a technological solution, until it becomes an innovation and generate impacts, are subject to interactions with the social, political, economic and ecological environment. The dynamism of ambiance may impel ou cause changes along the course of these creations and insertions of their products in the markets.

- **Contribution to the Global UN Policies on SDG** - This indicator should be applied in *ex-ante* and *ex-post* evaluations in Zone 5 (international or global environment), in order to verify the alignment between technological innovation and the United Nations sustainable development goals (SDG). Ideally is that each innovation generated contributes to one or more of these goals.

d) Economic Dimension and Descriptors of its Components

- **Profitability** – Making investments calculation and future predictions on profitability are essential measures, as also are the search for productivity and reduction of production costs, however, the market is a crucial part of this economic arrangement. It will be a business disaster if all planning come down due to market volatilities or unpredictable situations are faced.

Ultimately, what matters most to the producer is that he knows of his real profitability after the sale of his product or service, evidently with social and environmental responsibility. Therefore, this indicator was chosen to be evaluated, considering the greater interest of the user of a certain technological solution: its profitability post-sale, by *ex-post* evaluation.

This measure will be applied only for *ex-post* evaluation and it is restricted exclusively to the producer profitability on the adoption of the new technological solution by comparing with the previous technology, as follows:

P = Op/Ki, where P is profitability, Op is the operational profitability, and K is the capital invested in the activity.

Op = Or – Oc, where Or is the operational revenue, and Oc is the operational cost.

Oc = variable costs + fixed costs (including depreciation)

D= Iva – Fva / Ul (y), where D is depreciation, Iva is the initial value of assets, Fva is the final value of assets, Ul is the asset useful life, and y is the number of years.

It is important to work separately with Groups of Assets: infrastructure, machines, vehicles, equipment and so on.

- **Internal Rate of Return (IRR)** - This indicator will be restricted to the national spatial scale (Zone 4) and applied to the research organization that generates innovations, it is because will calculate the national average on the technological solutions that will be produced by the organization in its totality, over the period to be measured (one year, for instance).

In this case, the estimation of the IRR will be performed for each technological solution chosen to be assessed (in the *ex-ante* timing). Then, it has to seek the average result of all evaluated solutions into a single result for the research organization. So that there will be a final result of the rate of total investment in research versus its total economic return.

The IRR is a measure that indicates the percentage of the economic viability of a project or investment. The calculation is based on the Net Present Value (NPV), matching it to "zero". Therefore, the IRR of a research project is the rate that makes the NPV of the investment cash flow null and void, characterizing the rate of remuneration of the invested capital (Heckman et al., 2008)[16].

The IRR formula is calculated by equating the sum of the present value of future cash flow less the initial investment to zero. Since we are dealing with an unknown variable, this is a bit of an algebraic equation, according to the formula below:

Internal Rate of Return

$$\left(\frac{\text{Cash Flows Year 1}}{(1+\text{IRR})^1} + \frac{\text{Cash Flows Year 2}}{(1+\text{IRR})^2} + \frac{\text{Cash Flows Year 3}}{(1+\text{IRR})^3} + \frac{\text{Cash Flows Year 4}}{(1+\text{IRR})^4} \right) - \text{Initial Investment} = 0$$

The idea is to know how much capital is required to start the project and the research organization will have a reasonable estimate of the future income of the investment. It means that is necessary to solve for the discount rate that will make the NPV equal to zero.

Calculating NPV: It is important to know that the present value of a certain amount is the exact opposite of future value. The formula is the following: PV = FV [1/(1 + I)t], where PV is Present Value, FV is Future Value, and "t" is the time variable.

Due to its essential characteristics, by dealing with forecast return on certain investment, the IRR will be used solely to calculate the return of research projects in the *ex-ante* evaluation phase. Unlike the profitability measured after a solution is adopted, with actual expenditure and actual capital returns, from the sale of agricultural or agroindustrial products, or even after the sale of any service, software or other product not related to the production inside the farm (which can be measured and evaluated in the *ex-post* timing).

- **Access to Production Assets** - Literature and some field experiences come demonstrating that difficulties in adopting certain technologies in its integrality of concept, method, and stages can be related to access difficulties to its required inputs or even to the

---

[16] Heckman, James J.; Lochner, Lance J., and Todd, Petra E. (2008). "Earnings Functions and Rates of Return," Journal of Human Capital 2, no. 1: 1-31. Available at: https://doi.org/10.1086/587037.

immediately posterior phase of its adoption. It can happen when some solution is welcome at the beginning, but its continually using may make it unviable in the medium and long term, despite its short-term success, masking the impact, which can be highly positive in its early stages of time, on the other hand, can be disastrous in the medium and long-term.

In this way, the impacts can have wide variability between the positive and negative levels over time.

The user's difficulty in adopting a creative solution may be related to the cost of its implementation or difficulties in accessing all elements of inputs to enable its adoption with effectiveness. In this context, there may be obstacles to accessing bank credit, to design the production project using the new solution. Or even, can face logistic obstacles to access certain demanded inputs, or barriers to transport and storage products, resulting from production increase with the new technology.

Or, weaknesses in the rural technical assistance system in relaying with technical reliability the information necessary for the success of innovation, or even barriers to the acquisition of machines, equipment, software, drones, knowledge domain or even difficulties to transform knowledge acquired in practical skills, and cultural barriers that prevent attitudinal changes, among other factors.

This indicator aims to measure the capacity of the producer to access production assets (inputs) regarding the new technological solution (facilities or difficulties grade for accessing it). Thus, for comparative purposes and to determine the impact assessment through a conclusive way, this indicator should be used to assess the degree of difficulty or ease of using the previous technological solution as well.

This indicator measurement will be restricted inside the farm or propriety (first level of spatial scale).

- **Post-Harvest Agricultural Losses / Post-Production Losses** - This indicator aims to evaluate the impact of a given solution in-farm or in-firm (agricultural, industrial or service) focused on the monitoring process of the post-production stage. Sometimes technological solutions can be affected by involuntary and unforeseen negative impacts as secondary effects, after the technology adoption, not for its technological base itself, however, due to the basic production following stages (good practices of post-harvest, storage, transportation, packing, management etc.).

On average 30% of what is produced on farms around the world, for example, is lost in the post-harvest. “Food losses represent a waste of resources used in production such as land, water, energy and inputs, increasing the 'green' gas emissions in vain” (FAO, 2011)[17]. FAO establish a global policy focused on Food Losses (inside farms) and Food Waste (outside farms). This policy represents an answer to the UN Sustainable Development Goals (FAO, 2011). This indicator is directly linked with this program and the UN’s SDG, then its predicate has a strong bias towards the sustainable development principles.

Losses also occur in the productive processes of industries and services. This indicator intends to stimulate to produce innovation focused on controlling, avoiding, minimize and eliminate post-production losses, inside the farm or firm.

This indicator will evaluate the impact of the technological solution on these post-production phases of the production systems, including comparing with solutions previously adopted. The data collection will be restricted inside the farm or propriety.

- **Creation or strengthening of productive arrangement and supply chains** – This indicator apply to the municipal and state or regional dimensions (it is always important to remember that this approach is referred to the Zones 2 and 3 of figure 13, indicated in page 141 of the main text of this thesis), and can be adopted in *ex-ante* and *ex-post* evaluations.

The objective of this indicator is to verify the impact of a given technological solution about the creation or strengthening of some supply chain (indirect impacts) or even several unfolded from them (unfolded impacts).

Some chains can arise at the municipal level and across through the state or even through the national and international dimension. However, this indicator will be restricted in zones 2 and 3, by making a methodological cut, limiting its supply chain to the extension of state/region.

[17] Food and Agricultural - FAO. (2011). Safe Food - Global Initiative on Food Loss and Waste Reduction. Available at: http://www.fao.org/docrep/014/mb060e/mb060e00.pdf.

- **Innovation Contribution to GDP** - This indicator will measure added data related to all innovations produced during a certain period (an annual evaluation, for instance). It must be applied exclusively for *ex-post* evaluation and to State and National spatial scale (zones 4 and 5).

The adopted technological solutions with added value, with their effects to the productive sector and several supply chains (related to agricultural and industrial production, as well as trade segments and all agribusiness) must be analyzed on their reflexes to the state and national GDP during a year. It could be summarized by the research organization production and its contribution to national GDP and, for specific cases (related to specific projects or research units) to the state GDP.

- **Research organization influence on producers, firms or supply chains in access to international markets -** This indicator should be applied for *ex-ante* and *ex-post* evaluations and one 5, that is, by analyzing technological solutions which generate direct, indirect or unfolded impacts in the international markets, promoting or opening the external markets for domestic producers, firms and supply chains.

- **Consumers satisfaction** – This indicator will be applied to the zones 4 and 5 (national and international/global ambiance), for *ex-ante* and *ex-post* evaluation. Its objective is to assess the impact of a certain technological innovation which generates directly, indirectly or unfolded impact regarding the national and international market and allow consumers to be consulted about their opinions on products or services derived from analyzed innovation.

It also is a way to follow up long supply chain check by the national and international impact of a technological solution, through the wholesalers and retailers opinions about the products or services that they come buying and distributing.

1. Instruments (Tools) and Products of IIAMS

1.1 Instruments (Tools) of IIAMS

To guarantee the standard of process reliability, the IIAMS methodology recommends that an independent and external organization drives the impact evaluation process, despite it be oriented by this approach and tools.

The IIAMS embeds a series of instruments or tools to be applied according to the moment or stage of its implementation.

To collect data from stakeholders, it is recommended to use **meetings, semi-structured and structured interviews, beyond the adoption of questionnaires (to be applied on a case-by-case basis), on-site visits to collect information by observation of the specialist in the subject under analysis, especially for the environmental topic**. Even if one chooses to apply semi-structured interviews, it is important to have a set of questions as guiding thread, or at least the central themes and the main script to follow.

Following the literature on social research methods, especially about the semi-structured interview, it is important to consider the strategy of stimulating informal interrelationship moments. During our field experience in Mato Grosso we have validated this reality while observing how important is to maintain an open mind and certain skills in behavioral approaches to (based on the previous script) aiming to extracts important information along the informal conversations. In general, while interviewees are more relaxed they reduce psychological resistances and providing more reliable data, without the risks of the inherent barriers to what Freud calls the superego (mechanisms of defense), or values of social controls (Trivinos, 1987[18]; Freud, 1992[19]).

As stated earlier, whether the process of constructing innovations obeys criteria based on concepts of holism, constructivism, transdisciplinarity and agile leadership, this will certainly facilitate in the phases of impact assessment, since the actors will already be accustomed to the participatory way of innovation research organization to work, and the channels of interactions will already be paved.

As a result, there will be situations where structured questionnaires will not be required, but meetings with scripts will be enough to capture important data and information. On the other hand, if there is a need for questionnaire application or interviews, these will not cause the strangeness or resistance, since the stakeholders should be accustomed of having constant interaction with the research organization.

---

[18] Trivinos, Augusto N.S.. (1987). Introducao a Pesquisa em Ciencias Sociais – a pesquisa qualitativa em educação. Ed. Atlas, São Paulo, Brazil. ISBN 85-224-0273-6.

[19] Freud, Anna. (1992). The Ego and the Mechanisms of Defense. Karnac Books, 204pp. London, ISBN 1 85575 038 4.

An important tool that can be used in landscape assessment is satellite imagery, or aerial photogrammetry (from drones, for example). However, it is recommended to carry out on-site observations to validate image or geoprocessed data, though only some samples of properties and municipalities under analysis are visited.

These images can be used to verify the congruence between what the owner of the land or farm claims as conserved permanent preservation areas and what indeed exists in the real world. It is important to make clear that this data confrontation does not concern environmental inspection, but only in cases of evaluation of technological solutions that are related to the need to conserve these riparian forests or that are evaluating the environmental impact of recovery technologies in these areas.

To perform environmental data collection, for cases of natural resources as water and soil, it is recommended that researchers or technicians carry out this survey, with respective analysis by accredited laboratories. In the case of carbon emission assessment versus carbon sequestration, to establish a carbon balance of the technology solution under evaluation versus the previous technology, it is recommended to use one of the methodologies already in use by the conventional research on the theme.

To collect data to verify the impact of a certain technological solution on the state or country GDP, it will be unavoidable to use secondary databases and information, and eventually make an effort for tracking information along the impacts pathway by the supply chains, sometimes requiring contacts with producers federal confederation, state federations or local associations/unions.

In addition, to accomplish an effective traceability throughout supply chain and collect secondary data from productive sector, it will be important frequent dialogue with their representative organizations (agricultural, industrial and services segments), as well as will be essential interaction with financial and governmental organizations, by accessing information from institutions responsible for statistics from economic, social and geographical data.

In this way, it is essential to understand and penetrate along the supply chains pathways affected by one technological innovation, then, it is important to visualize an example of supply chain related to the agricultural sector or agribusiness segment.

In order to reinforce the understanding of agricultural supply chains, one can observe the figure 2, below. It displays a supply chain linked to the agribusiness where must be characterized every stakeholders', its origins, interests and needs as well as correlations aspects connected to other chains' members. From that information organization it is possible to create futures expected impacts, which have to be constructed with them.

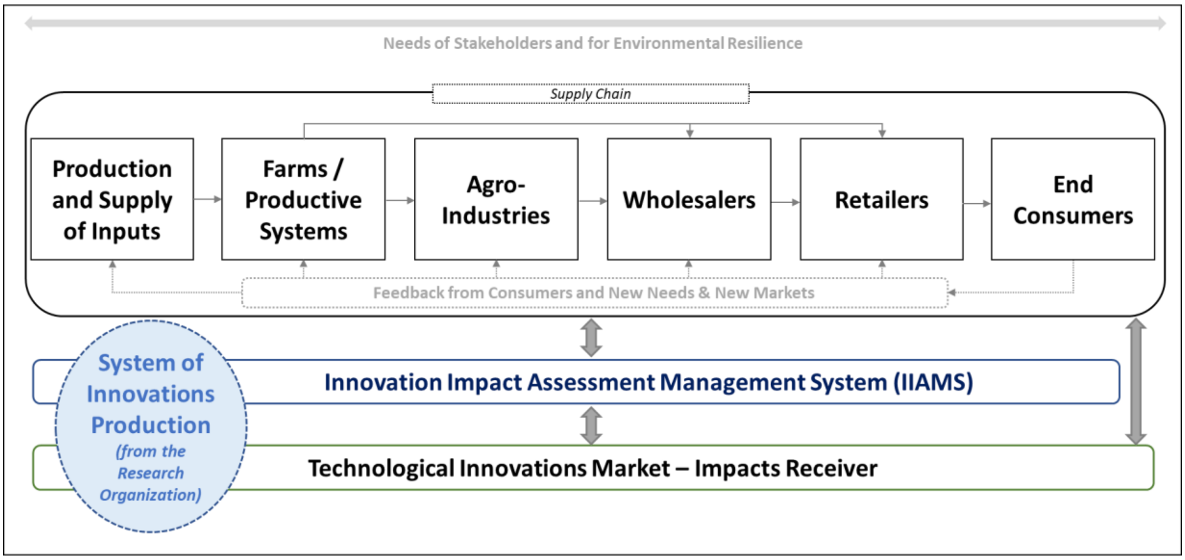


Figure 2. Agribusiness Supply Chain and its Relationship with Technological Innovation Market (Based on Castro et al., 1998).

Figure 2, above, demonstrates the pathway of superimposed impact on an agribusiness supply chain. In this way, interaction and dialogue with each of the components that make up the demand value chain must have a dynamic such as to avoid communication gaps at the key moments of *ex-ante* impact planning, throughout the process of innovation and at the end stage of the chain, when happening the impacts over time.

Observe that the needs of the environment so that it remains in a state of resilience, must permeate all the stages of the chain, interacting with it, since it involves the whole external environment, and therefore must be taken into account. The quadrant of the technological innovations market is an ambiance that is the recipient of market impacts, with its economic, political and social characteristics. IIAMS must interact with this market and with the innovation generation process, which is linked to the research and innovation organization.

Feedback from end-users is as important as that of each step in the supply chain. It allows assessing the market opportunities for innovations that other stakeholders (retailers, wholesalers, industrialists or farmers) may do not realize. It is also important to assess the positive or negative impact of the solutions adopted by each member of the production chain, given their final, indirect or long-term effects.

When viewing the supply chain as a whole, the research and innovation organization (with its activities done by the team of impact assessment management system) must interact with the input provider, a phase that happens before the activities within the farm or agro-industry. These input providers may also be users and clients of the research organization's innovations, or at least, they are indirect beneficiaries of it. Without the inputs they provide a technology may not reach its effectiveness at the time of its application.

It can also be observed that an agricultural producer can attend directly to the wholesaler and even to the retailer (in cases of family production or to a smaller scale for example), without having to go through agro-industry.

It should also be noted in Figure 2 that, from the stages of agro-industries, passing by the wholesalers to retailers and reaching final consumers, not only local, regional or national markets, but also international markets should be considered. Then, actors identification range get wider and integrate other different stakeholders, through several value chains that are unfolding as it extends to more distant markets and involves other segments, generating several indirect and unfolded impacts.

Many models that demonstrate supply chains sometimes forget to insert two important components, that is: Technical Assistance - TA and Marketing and Sale Management - MSM (they were not displayed in figure 2 to avoid visual pollution in the design by using excessive information, but they are described next).

The TA includes all types of technical assistance, on and off the farm (before or after farms), in industries, logistics and commerce, even in the case of technical consultancies and teams of experts in certain matters related to the adoption of innovations, involving training, workshops, monitoring and guidance on technological solution use.

MSM goes beyond TA because it involves monitoring user or customer satisfaction and represents important interaction with a key stakeholder: the end-user, by monitoring its impact pathway related to its satisfaction.

IIAMS methodology does not explicitly address the social balance theme or enroll a method evaluation on the social return of investments in research. Although that, it is a subject of extreme importance and deserves to be considered as enrichment to the items already recommended by this methodology.

The calculations that generate a monetization of social impacts must be added to the IIAMS strategic report. Whether this approach becomes important today for any organization, for research organizations supported by public resources this effort is much stronger to the concrete and measurable justification of its social return.

Often governments, financiers and society itself have no idea of the direct, indirect and unfolding impacts that innovations can generate in the social field. In this way, these monetization calculations are essential as tools to raise awareness of stakeholders and society in general.

Embrapa's Social Balance Report uses a tool validated by several non-profit institutions and reports the social impacts of the research. This approach can be applied in the scope of IIAMS, however, it is also worth adopting CSIRO's model of social return on investments, which has a structured, rigorous system based on broad interaction with stakeholders.

Social Return on Investment - SRoI is a set of stakeholder-focused assessment tools and cost-benefit analysis, quantifying and monetizing the organization's social impacts or its innovations. The method measures social impact basing it on three key performance indicators: fitness, effectiveness and efficiency. SRoI adopts an analytical rigor, besides a process that includes data informed by the stakeholders, which deepens the analysis, in a wide process of interaction with those who will be users or beneficiaries of the technological solutions, or by them affected. The SRoI is used by CSIRO in its impact assessment process, about the social component, based on a systematic approach from inputs up to impacts (CSIRO, 2015)[20].

Another important tool to be used along the IIAMS process is the "theory of change", also applied by CSIRO (2015). It is originated from the programs and projects evaluation. It is related to the construction of a model that specifies (usually adopting visual aids) the logic,

[20] CSIRO – the Commonwealth Scientific and Industrial Research Organisation. (2015). Impact Evaluation Guide. Available at: www.csiro.au, accessed 03/22/2018.

assumptions, influences, causal links and expected results of a program or project. To obtain this intent, it collects and analyzes performance data throughout the process until the outcome stage, evaluating partial results until reaching the assessment of final impacts (Jackson, 2013)[21].

"Theory of change is a generally cost-effective way to frame and inform an evaluation. Furthermore, it can be used in conjunction with a wide range of other data collection and analysis methods. In this sense, it is a flexible tool but one that, at the same time, promotes analytic rigor, learning and value for money" (Jackson, 2013).

Many leaders from industries have invested in alternatives to create positive social impacts beyond financial returns (Jackson, 2013; Brandeburg and Jackson, 2012[22]).

As a reference for data and information collection, Table 1, below, displays recommendable instruments and ways for making field survey, according to its every specificity:

Table 1. Instruments and Ways of Field Survey

Type	Way / Instrument
Declaratory (by the stakeholders: producers, public managers, entrepreneurs, members of the association, cooperative or productive chain, researchers, technical assistance workers, consumers, among others)	• Closed or open interviews (structured or semi-structured) • Informal dialogues
Measurement via specific equipment or methods and laboratory analysis (by the researcher or technician)	• Physical and biochemical analysis of soil • Physical and biochemical analysis of water • Environmental gas monitor for CO^2 (for example: in-built humidity sensor, soil respiration chamber, soil temperature probe…)
Analysis of images: satellite or aerial photogrammetric data (by subject matter experts)	• Geoprocessed and analyzed or untreated images • Photos
Assessment from on-site observation (by researcher or technician)	• Field visit, verification of incongruities or nonconformities

[21] Jackson, Edward T. (2013). Interrogating the Theory of Change: evaluating impact investing where it matters most. Journal of Sustainable Finance & Investment, Vol. 3, nº 2, 95-110. Available at: http://dx.doi.org/10.1080/20430795.2013.776257.

[22] Brandeburg, M. and Jackson, E.T. (2012). Impact Investing: Building and Industry. Presented to the Workshop entitled Impact Investing: Policy Framework in Africa, The Rockefeller Foundation, Nairobi.

	and conformities between data collected or observed locally versus laws, norms or protocols

1.2 Products of IIAMS

Especially applicable to agricultural research organizations, the IIAMS is a tool for planning and management, in supporting the institutional governance, by facilitating adjustments and continuous improvement in policies, project portfolios, research projects, and administrative processes, according to the stakeholders and society demands and aspirations, with environmental and social responsibility.

There are three reports as the InIAMS products: the **Innovation Operational Report by a cross-cut sustainability view (IORS);** the **Innovation Tactical Report by a cross-cut sustainability view (ITRS),** and the **Innovation Strategic Report by a cross-cut sustainability view (ISRS).** The first report with a set of detailed data and information, the second one with a greater degree of added information, and the third very summarized and focused for helping the decision-making from a widely strategic and institutional approach.

IORS is a synthesis of local impact analysis resulted in an applied technological solution, restricted to the farm or productive propriety, and fundamentally addressing the impacts of adopting a given technological innovation. It must be aligned with the tactical guidelines and Organizational Strategic Plan.

By making a comparative analysis of a certain innovation IORS is an important report to verify at a detailed level of technical information and operates as an important tool for verification, critical-constructive analysis, suggestions and decision making for researchers, technicians, and managers of innovation projects or operational processes of the research organization. Stakeholders, customers, and users linked to innovation are key parts to access this report.

ITRS is directly linked to the Project Portfolios, with added data and information from the operational report and aligned with the Strategic Plan.

ISRS is directly linked to the Strategic Plan, with added data and information from the tactical report. Below, figure3, demonstrates reports as products of the IIAMS.

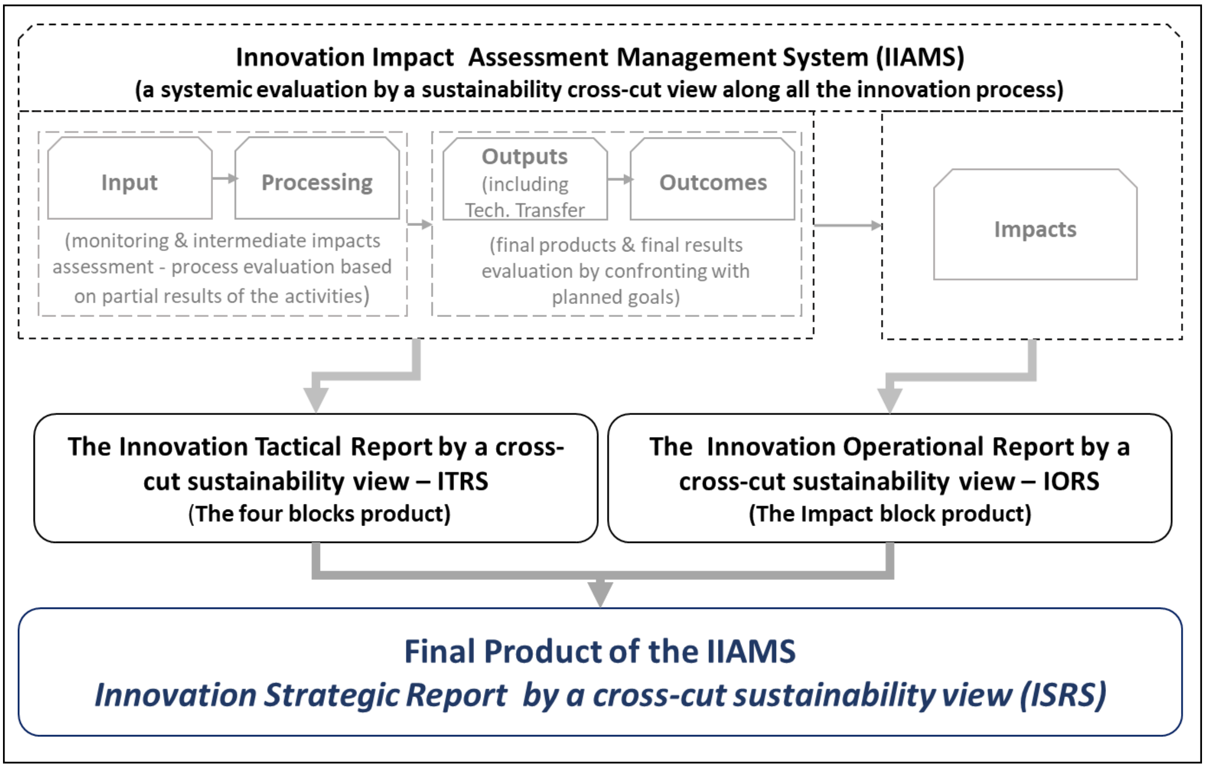


Figure 3. Reports of the IIAMS

Figure 3, above, shows how are structured the evaluation tools and the reports they generate, such as the products of the evaluation management system.

Note that the central focus of the IIAMS is to help the research organization to be more sustainable through its innovation process of solutions generation and adoption, with consequent and positive impacts to the economy, society and environment (included its stakeholders).

It will demand tactical and operational reports elaboration, which are essential for the development of the ISRS' content. This report also can help the decision-making process, as management tools of the innovation process, helping to (re)define or adjust future impact targets, outputs, results, and their *ex-ante* impacts, by viewing a cross-cut perspective, permeating all the organization.

The audience of the ISRS: stakeholders involved in the innovation process of the technological solution; producers; members of supply chains related to the solution; leaders of the units that participated in the innovation and leaders of the research institution; universities; other researchers, managers, and technicians of the research unit and institution; students.

After a comprehensive theoretical approach, with a respective conceptual and methodological description of the Model, a greater detailing should be contemplated in an **IIAMS Implementation Guide**, should not be part of this thesis, by considering its operational and organizational action characteristic.

Annex 5: Author's publication

Macrothink Institute™

Environmental Management and Sustainable Development
ISSN 2164-7682
2017, Vol. 6, No. 2

Sustainability Impact Assessment – An Overview with a Holistic and Transdisciplinary Perspective towards Agricultural Research

Savio Barros de Mendonca

University of Montpellier and IRD, France & Embrapa, Brazil

Anne-Elisabeth Laques

Institut de Recherche pour le Développement - IRD, France

Received: June 3, 2017 Accepted: June 27, 2017

doi:10.5296/emsd.v6i2.11333 URL: https://doi.org/10.5296/emsd.v6i2.11333

Abstract

It is important to insert agricultural research in this paper by considering it as a strategic area for providing knowledge and a technological base for agricultural production, considering that this sector generates outcomes with respective impacts to rural zones, supply-chain, economy, society and environment, representing a key piece for reaching United Nations objectives of sustainable development to each country and to the planet. Aiming to analyze how agricultural research organizations (as for instance: INRA and CIRAD, from France and EMBRAPA, from Brazil) have driving sustainability impact assessment methodologies and their interaction with transdisciplinary and holistic principles, using as a base innovation concepts. This paper will display an overview on concepts and approaches about sustainability impact assessment, but looking from a transversal perspective, passing by an historical description on impact assessment and on concepts related to sustainable development and sustainability. We will search for unedited models of sustainability impact systems by converging holism, transdisciplinarity and sustainability. There are several methodologies but few demonstrate an integrated view with a transversal perspective. It is also imperceptible any concrete governance-managerial system for sustainability impact assessment, considering every stage of the process, from a strategic to an operational level, including, analyzing environment, economy and society dimensions as one unique perspective. Such as a complex and multidimensional sector of economy, agricultural research requires profiled sustainability impact assessment with an innovative and dynamic approach.

Keywords: Sustainability, Impact, Assessment, Holistic, Transdisciplinary, Transversal

1. Introduction

From a general contextualization toward expectation and goals

This paper aims to identify conceptual approaches, methodologies, advances and challenges as well as to discuss and make inferences on sustainability impacts assessment; accomplishing analysis with an integrated, holistic and transversality perspective, analyzing some types of existing methodologies, systems and indicating the best applicability for each one. Concepts and methodological approaches will be analyzed toward research and innovation institutions, especially those used in the agricultural sector. In this scope, for evaluating sustainability impacts of any research organization it will be necessary to assess impacts of their products, technologies, processes and services. This effort will demand reviewing some conceptual bases related to impact assessment and the dimensions related to the sustainability principle, followed by reviewing the real concept of holism and transversality of knowledge. All the collected information will permit confronting the theoretical ideal world and the complex and conflicted real world. By retrieving approaches we can identify that environment and social-economic issues, historically, was main vectors for the first extensive discussion on impact assessment systems. Finally we will make a reflection on future expectations of innovative impact appraisal processes.

To address sustainability on the planet it is necessary to think about sustainable development policies in the nations and the respective compliance between them and endorsed international concepts, agreements, laws and protocols on sustainable development driven by United Nations (UN) and its derivative programs and initiatives, and especially considering the level of sustainable behaviors internalized by public organizations, private organizations, nongovernmental organizations and citizens. All of them are the representatives of the nations, and human life depends of their actions in the real world.

Despite efforts from several national governments and organizations around the world that incorporate concepts and guide-lines on sustainable development in their policies and strategic plans, the distance between what would be reasonable stage to the hard reality is visible, especially if we consider the level of people that have internalized principles toward sustainable behaviors. After 20 years, since Rio-92, it was clear that a huge gap existed between idealized sustainable development and the real results reached by nations: the feeling of frustration showed for great part of global leaderships boosted the UN representative members to identify different actions to drive Rio+20 Conference, its processes and reports (UN, 2012).

In this paper we are going to restrict our analysis to the organizations in general, and especially those used in the agricultural research sector. The organizations (public, private or nongovernmental) are the entities through which policies, plans, programs, projects, processes and activities are accomplished: as a final result, organizations generate products and services and their impacts. Thereby, to verify if the world will walk towards the sustainability direction, one of the most fundamental mechanisms is to evaluate the impact of the organization's policies, programs, projects, products, services and activities.

There is a program theory that analyzes how a project will, or has, generated impact. This program theory comprises the tracking of results or of the impact pathway. This process begins with the project input; passes by the output stage, followed by a chain of intermediate outcomes that are followed by extensive and often longer-term outcomes. The GTZ, Germany cooperation organization (currently GIZ), adopted this program theory evaluation to guide their projects impact assessment. This approach has a two-phase assessment, the first one is used to guide a self-monitoring and evaluation, and the second phase is an independent ex post impact assessment (Douthwaite, 2003) "that would normally be carried out several years after the project has been finished" (Douthwaite, 2003).

The pathway approached by Douthwaite creates the theoretical base for assessing *ex-ante* (as planning phase) and *ex-post* (as outcome phase). Based in these approaches it is recommendable that evaluation considers the *ex-ante* and *ex-post* analysis, the first one as a sense of prevention and the second one as a mechanism for feedback and correction of the project's planning and management.

This paper methodology will be based on a literature review and practical cases of some organizations. A historical synthesis on the theme will be made and will present a condensed approach about concepts of: Sustainability Assessment, Sustainability Impact Assessment, Integrated Assessment, Holism and Transdisciplinarity and adjacent concepts to these issues, as well as description on some organizations experiences from the perspective of case studies.

2. Contextualization: Overview on History, Approaches, Problems and Concepts

2.1 Brief Historical Approach and Problems

The Limits to Growth published by the Club of Rome had relevant impact in the world when in the early 1970s demonstrated how fragile the planet was due unreasonable use of resources. The Brundtland Report evidenced that greedy production systems provoked degradation and depletion on natural resources and negative impact on the planet. This report coined the bases for sustainable development definitions endorsed by United Nations in the Rio Earth Summit by Agenda 21 (Bond and Morrison-Saunders, 2011).

The first important reaction of negative environmental impacts occurred in 1969, in the United States, when the National Environmental Policy Act (NEPA) was created, as resulted from pressure of the popular movements in that country related to environmental questions. In the scope of NEPA initiatives, beginning in the early 1970s emerged the legal base, the methodology and the procedures of Environmental Impact Assessment (EIA) and next, the Social Impact Assessment (SIA) which also included economic impacts addressed to large-scale projects. These instruments merged as part of social sciences and as components of the policy-making process (Freudenburg, 1986).

At present there are several models and systems for impact evaluation such as: social, environmental, technological, economic and fiscal (Becker, 2001), as well as health assessment (Wernham, 2011). In the last 15 years companies have been publishing social and environmental reports as tools of accountability which means transparency for stakeholders, also as an instrument of social and environmental responsibility, e.g. Sustainability Report based on GRI – Global Report Initiative (GRI, 2017).

2.2 Concepts and Approaches

2.2.1 Economic Assessment (EA)

The economic assessment, that forms part of the social impact assessment, aims towards examining all aspects that might contribute to the gain or loss of individual, community, regional or national resources. An economic impact analysis examines the effects of a policy, project, or event on the local economy (MasterQResearch, 2010). Economic impacts assessment of an organization can be analyzed by verifying direct impact, indirect impact and induced impact. The first one is the economic benefit that resulted from all activities and products generated by the organization; the second one is directed to the economic benefits and employment generated to the connected supply chain of the products and services produced by the organization; and the third one represents the benefits that arise when employees of the organization and its supply chain spend their earnings, locally or anywhere (Oxford Economics, 2015). The catalytic economic impact is a relatively new concept that shows long term effects on other different productive chains or organizations or other sectors of economy (Oxford Economics, 2013). Alston (1995) consolidates his approach and econometric theories applied to the agricultural sector by focusing on economic impact analysis of agricultural technologies and research projects and their effects to the agricultural producers and the consumers.

2.2.2 Environment Assessment

The International Assessment Impact Association – IAIA defines impact assessment as a "process of identifying the future consequences of a current or proposed action" (2006). Based on the first concept for environmental impact assessment defined by NEPA, added by several global discussions in the UN conventions and international meetings, UNEP defined EIA as an instrument for identifying environmental, social and economic impacts of specific projects which must be elaborated before their decision for design and implementation (UNEP, 2004). The Convention on Biological Diversity – CBD (2006) defines EIA as a process of assessing possible environmental impacts of a proposed project or development initiative, considering socio-economic, cultural and human-health impacts, by taking into account that all the dimensions are interconnected, identifying both positive and negative effects. If EIA are implemented to assess the effects of individual or operational projects, a wider evaluation can be applied Strategic Environmental Assessment which is suitable to appraise policies and programs (CBD, 2006). According to Sadler and Dalal-Clayton (1999) "Strategic Environment Assessment (SEA) is conceptualizing as the formalized, systematic and comprehensive process of identifying and evaluating the environmental consequences of proposed policies, plans or programs to ensure that they are fully included and appropriately addressed at the earliest possible stage of decision-making on a par with economic and social considerations. In order to improve the quality of policy processes towards consistent sustainable development strategies, the European Commission implemented an impact assessment (IA) which was elaborated to be a process that could provide data and information for policy decision makers, demonstrating advantages and disadvantages of a possible policy and its effects (De Smedt, 2010). According to FAO (2012), EIA is a tool for decision-making process, important tool for identifying potential environmental risks for new projects. It is an important support for prevention, mitigation, management and monitoring measures. FAO adopts an approach to measure *ex-ante* impacts for operational initiatives, but it is also used for policy dialogue with countries before begin projects (FAO, 2012).

To help organizations identify, manage, monitor and control the environmental impacts related to their activities it is fundamental to construct an environmental management system, especially using an integrated approach with a holistic perspective (ISO, 2015). Toward this vision, ISO set the voluntary norm ISO 14001 designed to orientate how organizations can implement environmental management systems, step by step. As a consequence of that, ISO created the Life Cycle Sustainability Assessment (LCSA) ISO 14040 norm, as a voluntary standardization, aiming to be adopted *ex-ante* of implementing projects and activities. It is also important to consider ISO 26000 - Social Responsibility Guidance Standard as technical reference for enlarging analysis by integrating social responsibility with environmental responsibility, generating an integrated impact assessment (UNEP, 2011).

2.2.3 Social Assessment

In accordance with the Becker concept (Becker and Vanclay, 2003) Social Impact Assessment (SIA) is "the process of identifying the future consequences of a current or proposed actions which are related to individuals, organizations and social macro-systems". To Vanclay, social impact is: "the process of analyzing and managing the intended and unintended consequences of planned interventions on people so as to bring about a more sustainable and equitable biophysical and human environment".

In view of SIA being considered as a continuous process, not limited by technical practices, it is complicated to set limits (Becker and Vanclay, 2003).The current tendency has been to aggregate the economic with social assessment as part of impact studies. Then, we can consider socio-economic impact assessment (SEIA) as just one approach. It is also important to consider that the traditional environment impact assessment analysis has being to include the socio-economic studies into the EIA approaches. In this case, SEIA intends to identify and evaluate the potential socio-economic and cultural impacts of a proposed development projects on the lives and circumstances of people, their families and their communities. "If such potential impacts are significant and adverse, SEIA can assist the developer, and other parties to the EIA process, find ways to reduce, remove or prevent these impacts from happening" (The Review Board, 2007).

It has been usual to insert health impact to the social impact - it was apprehensible some decades ago, when the first steps of impact assessment processes were rehearsed. Nowadays the health theme wins space in the concern of people, organizations and countries towards the search for quality of life. Thereby, health analysis tends to be amplified into social impact assessment. "Health impact assessment is a structured process that brings together scientific data, public health expertise and principles, and stakeholder input to identify the potential health effects of a proposed policy, program, project, or plan and to craft health-based recommendations" (Wernham, 2011). In accordance with the Gothenburg consensus paper (ERCHP, 1999) Health Impact Assessment - HIA is defined as a set of procedures, methods and tools that must analyze and foresee risks for the health of a population and other possible consequences within the population.

2.2.4 Sustainability Assessment

Brundtland report that was main base for conceptualizing sustainable development, recognizing that sustainability derives from this concept root: "Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs"(UN, 1987). In 1992 and from this base-concept, the United Nations made critical considerations about decision-making process of nations and organizations which separated in their analysis, policies, projects and actions the social, from economic from environmental dimensions. Based on that argument, UN inserted at Agenda 21, the definition of sustainable development as a process that have to consider socio-economic and environmental issues as one fully, inseparable and integrated components, which will require broader range of public participation (UN, 1992). In fact, there are gaps among United Nations sustainability concept and many organizations and projects in the practical world. Reality demonstrates that policies, projects and actions of many institutions and companies still separating these dimensions.

This item, search to recover the importance of sustainability original concept and to demonstrate the necessity of enlarging from environmental, social or economic dimension to an inseparable and integrated view among these three components, especially when referring on assessment processes. The objective of sustainability assessment is to guarantee that strategic or operational actions become a positive contribution to sustainable development (Verheem, 2002). Sustainability assessment is a tool created to support policy-makers and decision-makers to minimize or avoid negative impacts or optimize positive impacts, aiming to make society more sustainable today and in the future (Pope et al, 2004). The broadest discussions related to environment assessment recommends inserting social and economic dimensions into the environmental scope, reflecting the three pillars of sustainability (environmental, social and economic) and resulting in form of integrated assessment, also called the Three Bottom-Line - TBL (Pope et al, 2004). Integrated assessment is also defined as "an interdisciplinary process of synthesizing, interpreting and communicating knowledge from diverse scientific disciplines in order to provide relevant information to policy-makers on a specific decision problem" (EEA, 2001).

Several methodologies based to integrated assessment models - IAMs approach, have been developed since the 1980's. Despite its use in other areas, this approach has been essentially focused on climate change issues. Due to its flexibility and adaptability feature many models have been developed and adapted based on IAM. With an interdisciplinary outlook, this approach considered complex analysis interfacing social-economic and environmental dimensions by its subcomponents, especially related to energy and long term effects resulted from simulations of future scenarios (Yang, 2016). As a framework based on the scope of the

European Union, a process of IAM has been proposed as a means for reaching better results in the *ex-ante* assessment, as well as improving the management of complex systems (Harris, 2002). IAM represents a mix of disciplinary models, using quantitative methods and producing several sustainability indicators (Ewert et al, 2015). With an interdisciplinary vision and considering three dimensions of sustainability, Sustainability Impact Assessment – SIA is a methodology addressed by OECD focused in social, economic and environmental dimensions, *ex-ante* from policies and programs on a strategic level, analyzing potential impacts of policies before their implementation, as well as, offering alternatives for decision-makers by alerting the possible risks and opportunities (OECD, 2010). Participatory Integrated Assessment is an integrated approach that, necessarily uses, stakeholders participatory method, as for instance in analyzing agricultural systems of production (Delmottea et al, 2013).

Sustainability Reports based on GRI is a periodical report published by private and public organizations as a way of demonstrating to consumers, clients, stakeholders and to the society at large, its sustainable responsibility level and performance based on their annual activities. With this report organizations have to show positive and negative results and impacts from their processes and products. Besides economic, social and environmental dimensions, recent reports have also been including financial and non-financial performance and have an accountability report. Partners of company and financiers feel safer to continue investing in the company and public organizations can demonstrate transparency and establish more trust for a better relationship with the government (GRI, 2017).

2.2.5 Holism, Disciplinarity, Multidisciplinarity, Interdisciplinarity and Transdisciplinarity

Holism was firstly defined in 1926 by the South-African Jan Smuts. He said: "the whole is more than the sum of its parts. The entire universe was based on an innate tendency for stable wholes to form from parts" (Gatherer, 2010). Against reductionist approaches, the holistic approach requires a comprehension of complex systems based on an ensemble of hierarchies that go from the macro level to the nano level, from the universe to subatomic particles. "For a cell biologist, holism might mean thinking about the whole liver". Depending on the context it might mean the "whole person, the whole community, the whole of society, or the whole planet". Then the scale will define your context to apply the holism concept (Freeman, Joshua, 2005).

To reach the transdisciplinarity concept it is important to begin by understand disciplinarity, multidisciplinarity and interdisciplinarity. Disciplinarity can be understood as a category to scientific knowledge organization, divided according to typical specialization. Despite each specialization it is set into a wide scientific grouping, due to its own border, each discipline tends to reach its autonomy by its own theories, techniques and languages. If we just assembly several disciplines we have multidisciplinarity. Yet, this approach focused to the (mono) disciplinarity, especially from the 1950s, does not refuse the classical science and also does not compete with it. Even so, a knowledge revolution begun by Physics has quarreled with ideas of order, separability, reduction and classical logic, transforming and changing the prevailing scientific paradigm (Morin, 1990). Then, as a second knowledge

Environmental Management and Sustainable Development
ISSN 2164-7682
2017, Vol. 6, No. 2

revolution systemic sciences came to re-arrange disciplines around interaction complexes or of one object that can be called a system (Morin & Le Moigne, 2003). The world has been evolving towards a new dynamic of life that requires not only new discussions on multidisciplinarity, but new attitudes toward transdisciplinarity. Recently cross-cut vision and integrative behavior have been required for business management as well as for academy, science & innovation (Roquete et al, 2012).

According to Piaget (1972) the approach on interdisciplinarity, represents a cooperative process that results from real reciprocities among people (scientists, specialists, technicians or professionals) and mutual enrichment, however, transdisciplinary research is a new trend for knowledge construction (Cohen and Lloyd, 2014). In the information or knowledge society, there is a need for transdisciplinary research, i.e., research that deals with complex life-world problems. Transdisciplinary projects aim to come up with practice-oriented solutions that serve what is perceived to be the common good. In order to achieve this, they transcend disciplinary boundaries and include the perspectives of public agencies, the business community and civil society in the research process (Hadorn and Pohl, 2007). "Transdisciplinary projects are those in which researchers from different fields not only work closely together on a common problem over an extended period but also create shared conceptual models of the problem that integrates and transcends each of their separate disciplinary perspectives" (Mitrany & Stokols, 2005). "Transdisciplinarity is a principle for organizing processes of mutual learning and problem solving between science and society. Thus, transdisciplinarity may contribute to sustainable development" (Scholz, 2000).

2.2.6 Impact Assessment – by an Integrated Perspective

This article's core is impact assessment, by a sustainability perspective. Then, it is essential to define "assessment" and "impact". Assessment implicates in quantitative and qualitative analysis, making estimates or valuation and can be focused on four objectives: 1) evaluate processes; 2) evaluation of generated products/services; 3) evaluation of generated outcomes; 4) evaluation of generated impacts (to the environment, economic and society - farmers, industries, services, local, regional and national governments, stakeholders and consumers). Impacts have two dimensions to be considered: a) the scale (local, intra-regional, national and international) and b) dimension time (short, mid and long term of effect, as well as, passing time or continuous effect). Impact is defined as the positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended. These effects can be economic, socio-cultural, institutional, environmental, technological or of other types. Organizations have to be capable to use all results of impact studies to deliver accountability to stakeholders (Bantilan et al, 2014).

To understand impacts as broad or long-term effects and about its pathways stages require some basic definitions. The stage outputs means the products, services or facilities that result from planned and accomplished solutions. Outcomes are impacts resulted from solutions (products, services and facilities). Before making product and service impacts appraisal (*ex-post*) it is essential to assess those processes before implementation (*ex-ante*) as a preventive measure. This is necessary because, after they have been generated, products and services will affect the environment and people who are direct or indirect user's of those solutions, and their effects will reflect on stakeholders, and may also affect government policies, all of which can generate reflexes for the short term or even for many years (NCVO, 2017).

Since the end of the 2000s, pressured by innovation chains and induced by industries and production systems, as well as, due to government rules towards good use of public resources, normally imposed by financial resources restrictions, many countries have been impelled to develop systems of impact assessment (Ruegg & Feller 2003). Research Impact Assessment – RIA, experienced especially by agricultural sector research institutions, search, mainly, to evaluate the impact of research to the economy and society, from an *ex-post* analysis (Joly, P. et al., 2016). RIA has been interesting for organizations that work on science and innovation, research ecosystems and about studies for management effective of research funding, and especially as an approach adopted by public organizations especially to measure economic and social impacts of its research, as also a form of accountability for governments, partners and society (ISRIA, 2017). Especially focused to study and evaluate policies generated by European Union, the Impact Assessment Institute was created in 2015, and, according to its vision, 'impact assessment' covered all processes of a policy, from the conception stage, passing by the legislation phase, to its implementation stage and consequent impacts, until the construction of a new policy, requiring monitoring and respectively *ex-ante* and *ex-post* appraisal (IAI, 2017).

When we analyze the UN Sustainable Development Goals, we can identify how agriculture represents a strong sector for reaching these goals. From the 17 goals established by the UN, goals 2, 3, 6, 8, 12, 13 and 15 have direct relation to the agricultural activity and their impacts to the environment, economy and society. This reality leads us to converge our impact assessment analysis to this segment, with a special focus to research organizations and taking into account their impact evaluation systems for solutions (technologies, products, processes and services) for producers, supply-chains and society (UN, 2015). CGIAR is a global research organization that congregates 15 agricultural research centers around the world (CGIAR, 2017). CGIAR Research Impact Assessment evaluates *ex-post* impacts of their developed technologies when used in the field and creating links from generated data and information to support *ex ante* assessment and orients plans, as a way to improve research management and to be transparent for their financiers (Merrey, 2015). In France, there are two important agricultural research institutions: INRA (L'Institut national de la recherche agronomique, in English, the National Institute for Agricultural Research) and CIRAD (Centre de coopération internationale en recherche agronomique pour le développement, in English, Center for International Cooperation of Agronomic Research for Development, whose mission is to contribute to the agricultural innovation and research development in countries of the south). For some years, both institutions have been developing systems for evaluating impacts of their agricultural research, primarily focused on the socio-economic impacts and more recently they have included the environmental dimension. INRA believes that research contributes not only to generate scientific knowledge, however they have to be directed towards agriculture, supply-chain, food, and environment by means of innovating in production. Based on the RIA approach, this institution implemented a document called ASIRPA, which represented in a methodology for analyzing effects from their research, with strong emphasis on agronomic and socio-economic impact to producers and supply-chain (Colinet et al, 2014).

Named Impress (IMPact of RESearch in the South), CIRAD has developed a system for evaluating impacts of its technologies production. This organization understands that to assess impact it is necessary to grasp recent innovation concepts and how the innovation process demands a collective complex interaction among actors. CIRAD (Barret et al, 2015) says that, the main role of a research institution is to develop research, but when it goes facing real world, sometimes the cause of impact results from different activities that are not necessarily derivative from the research, due to current speed of information, and dynamism of the processes of creativity and innovation. Interaction among different actors generates complex combinations for identifying technology demands and risks of unpredictable, diffuse and complex impacts. Therefore, to analyze impacts it is necessary to connect policies - strategic plans - programs - projects - processes - activities and products/services and understand that for construct all this process demands an open innovation perspective (technological innovation and/or management innovation) and an active inter-relationship with co-creation assembling actors along the whole process. While research contributes, sometimes strongly, to impact, it does not mean that some impacts can result from lack of interaction with research. To analyze impacts we may use two pathways: *ex-ante* (will analyze relation among programs, projects, out-put / outcome supported by an hypothetic path and projecting expected results and impacts) and *ex-post* (comparatively analyzing what was planned and what was reached in terms of the outcome and its consequences on development) (Barret et al, 2015).

Since the 1970's Brazilian Agricultural Research Corporation – Embrapa has been developing systems for impact assessment. At the beginning focused on economic impact analysis, especially due to the financial restrictions for the public sector, by considering that this organization is essentially supported by governmental resources and impact analysis would be a way to demonstrate to the federal government its institutional and economic effectiveness. After the 2000's impact analysis became multidimentional by including social and environmental dimensions as part of this process, generating a Social Balance, based on integrated impact assessment and mainly supported by a methodology called Ambitec-Agro (Rodrigues et al, 2010). Recently, as a result from a request of the Brazilian Supreme Audit Institution, Embrapa has inserted Social Balance as part of its financial and accountability report, generating an integrated report which reflects the social, environmental and economic impacts resulted from its technologies and the services produced, as well as, demonstrating its transparency concerning the government's and society's expectations on the application of its resources (Embrapa, 2017).

3. Methodology

The discussion method will adopt confrontation between the practical world of organizations versus ideal world of concepts, as well as, the possible limitations on the appraisal process under a holistic and transversal insight. At the discussion stage qualitative analysis will be adopted. Thus, this paper will adopt the following stages:

a) **Literature review** - a bibliographical review was made, with scientific papers and books, aimed at carrying out a historical rescue of themes such as sustainable development, sustainability, evaluation, impact, holism, transdisciplinarity, evaluation of economic, social and environmental impacts and through an integrated perspective of sustainability assessment.

b) **Insertion of current scenarios on the issue** - we carried out a survey of information related to the application of sustainability impact assessment approaches, with a special focus on research organizations, including a correlation analysis with concepts and innovation processes.

c) **Synthetic case study of some organizations** - case studies represent a methodological way to research current reality, as well as to confront theory versus its applicability, including the identification of gaps between these two points. In this direction, we have made a synthetic case study, aiming to confront the concepts and approach on impact assessment versus the practical world, in this case, applied to three agricultural research institutions: INRA, CIRAD (both from France) and Embrapa (from Brazil). Despite local environmental, social and economic different realities, the objective of this comparative analysis was to identify methodological aspects.

d) **Inferences and conclusions** - along the process of discussion and conclusions, some comparative analyzes and inferences about the concepts and reality researched were carried out, indicating the need for future complementary research related to the work carried out, including deepening some issues that, due to the methodological and structuring aspects of this article, were not possible further study.

4. Discussion

After concept and approach sequences, as well as, a historical overview concerning impact assessment and sustainability, now we are going to confront them with holism and transdisciplinarity approaches and taking an overview on how some agricultural research organizations have being studying and working with impact assessment and their solutions (technologies, products, processes and services).

To create a planetary sustainable society it is necessary that organizations and people of countries adopt sustainable attitudes. Evaluation impact systems will operate as an azimuth and thermometer indicating the grade and correct direction towards sustainability. If it is apparently irrelevant to measure the individual impacts of the global population, in spite of its complexity, it seems more important to assess collective, organizational, policy, plan, project and service impacts, although small cumulative impacts can generate large and lasting effects to the social, economic and ecological environment (Eccleston, 2011). Private and public organizations are responsible for implementing policies, plans, projects and activities and generate products and services. All of them provoke some sort of impact on the environment, economy and society, on the local, national or global space scale, with effects through the supply-chain and by diffused ways, during a variable time scale. Organizations have to adopt a creative and proactive competence as a way to identify stakeholder's diverse needs and demands (Asif et al, 2011), as well as, ways of managing internal conflicts and impacts from their production to the society and environmental (Chowdhury, 2013), it means to concentrate efforts to create an internal sustainability culture for facilitating the generation of sustainable impacts from their processes, products or services.

This analysis drives us to question the ways used for assessing sustainability impacts related to organizations and their policies, plans, programs, projects, processes, activities and respectively products and the services generated. If we lead this discussion to public research institutions and directed agricultural research organizations, current concern toward sustainability are still fragile and we can view potentially disconnected impact evaluation systems by a great part of these organizations. Among other issues, deforestation, loss of biodiversity, water scarcity, pollution, climate change, poverty, hungry, social inequity, economic crisis, all these questions have interconnection with the agricultural sector and have been hardly discussed around the world, and several global policies, agreements and programs have been driven by multilateral organisms and some national, multinational or local organizations, but there are clear gaps between policies and concrete results. Lately interest in sustainability research has grown, "however, the mainstream scientific methodologies are often poorly equipped to deal with complex sustainability problems" (Popa et al, 2015).

Transition Management (TM) has been a recent interdisciplinary approach in attempt to answer new ways for governance into complex and multiple scenarios, immersed in uninterrupted change and uncertainties demanding a sustainable society. These approaches (experienced by the Dutch government) search to adopt flexible and adaptable structures for working into an ambience with fragmented policies that requires resilient behavior, stimulating knowledge and technological changes, innovation and incremental improvements, especially paying attention to relevant actors. TM creates adequate conditions for legal compliance and for navigating with effectiveness in this dynamic social, economic and ecological environment (Loorbach & Rotmans, 2010).

Therefore, TM is a holistic approach that operates under a transversal vision and asks for systemic models that can view from policy/strategy stage, passing by tactical, operational and monitoring /evaluation stages, and understanding that one stage cannot be effective without another. Sustainability Transition is a field of research intrinsically linked to the transition management approach. In fact, it denotes a new field for thinking outside of traditional approaches and intends to exit from traditional social-technical vision to a more sustainable mode of production and consumption. Besides traditional disciplines as ecology, biology, agronomy, sociology and economy, impact assessments have to enlarge for other areas participation in their argumentative and integrative process. Sustainability transition approach includes: economic geography, philosophy of science, science of education, science of health, science of policy, management studies, information technology and several fields normally not considered in impact assessment processes. Empirical insights are as important as a scientific outlook (Markard et al, 2012).

Transdisciplinary approaches require attention on three aspects: cognitive, structural, and processual. "Effective cognitive leadership provides a vision that links and motivates transdisciplinary researchers to step beyond their disciplinary lens, relax old assumptions, and search for creative frame-breaking solutions. Effective structural leadership adds value by creating needed bridges among unconnected parties. Effective processual leadership encourages trust and turns potentially destructive conflict into constructive interactions" (Gray, 2008).

In effect, we will not find perfection in just one approach and challenge is to use a magnifying glass to filter each good contribution to structure a more complete, in-depth and holistic methodology. It is a reasonable multidisciplinarity; but, interdisciplinarity represents an advance over multidisciplinarity, because in human relationships processes, only, transdisciplinarity is a wider approach, with the exercise of empathy, including social and all stakeholders participation for policy and project construction, no restricted to scientists and policy makers. Hence, we need to respect all areas of scientific knowledge, the traditional knowledge and valuable savvy tied to professional and life experiences. It is necessary to adopt a mind opening attitude for new learning and experiences and thus, permit the construction of a hybrid approach, multidiverse and responsive to the height of complexity that the issue requires. Transdisciplinarity demands an open mind and attitude to auscultate the others, including citizens, consumers, all kind of producers, representative members of society, that is basic for construct sustainable societies (Popa et al, 2015). Scientists who are working with sustainability issues recognize the urgency to migrate from restrictive multidisciplinary and interdisciplinary approaches towards transdisciplinary collaborations, which implicate to join scientific and extra-scientific expertise (Popa et al, 2015). Holism and transdisciplinarity are two transversal necessary components for reaching effectiveness on impact assessment analysis either *ex-ante* or *ex-post*.

Usually Economic Impact Assessment is adopted in private organizations relating aspects of marketing and investment feedbacks. In public organizations it has been used as part of an integrated assessment processes for *ex-ante* or *ex-post stage*. It has a strong microeconomic component when it refers to individual organizations or farm economic results. Or yet, can be used to show economic performance and accountability, also applicable to public organizations. In agricultural research organizations it has been used for evaluating impact from generated and adopted technologies, with consequent effects over supply-chain and reflexes to local or national income. Despite its operational application, its results are important for strategic analysis.

In general, Social Impact Assessment is aggregated to economic assessment; it has not being adopted alone and has been an important component on integrated assessment processes. This dimension approach is according to the type of project, namely, and can include aspects such as: health, nutrition, education, cultural, citizenship and others. SEI has been adopted in assessment processes which hold economic and social dimensions, without the environmental component. But, in fact, it is a way to display clearly that both dimensions have been joined in just one package during analysis processes, with expectations that balance between social and economic dimensions. HIA Normally is adopted in activities related to the health sector.

It could include much more in every impact assessment processes, because human health is directly or indirectly influenced by all economic activities or development projects, or even by research projects, especially in agricultural activity, both at the production stage and in the food chain.

Historically EIA emphasizes environmental aspects by its analytical process, although it includes social and economic dimensions, with more or less stress to one or another. Undoubtedly a great part of real cases demonstrate environmental and social emphasis, as FAO EIA methodology, that is frequently adopted for agricultural projects, what is naturally expected due environmentalist origin of EIA, and considering that economy depends on a good social quality of life and both dimensions (economic and social) are inserted to ecological environment. SEA is applicable to policies, plans or programs with expectation of large impacts to environment and/or relevant social and economic effects, through short, mid or long terms. This approach has generally been applied by government organizations, but also by big companies. Really it could be adopted in much larger scale for any kind of organization as part of its strategic plan to orientate tactical and operational activities regarding environmental, social and economic impacts. By considering three dimensions of sustainability, Integrated Assessment – IA (TBL=Three Bottom-Line) approach has demonstrated a larger multivision than only environmental vision with an operational scale, it has normally been directed to the *ex-ante* stage of project that demonstrates clear impact risks to environment and society before implementing projects. SIA is an approach adopted by OECD, with detailed analysis of potential risks and opportunities according to an environmental, social and economic perspective. Even if it is restricted to a policy or strategic level, it effectively demonstrates its sustainability approach and efforts to be interdisciplinary, despite showing certain complexity or low practicality to be implemented.

IAM is adopted by many groups and institutions, as for instance: European Union and for provisioning of conceptual basis for Intergovernmental Panel on Climate Change- IPCC. This approach has been applied to evaluate risks and opportunities by environmental and socio-economic dimensions related to policies and plans. Considering many disciplines in its analysis process as: economic feasibility studies, anthropogenic greenhouse gas emissions and climate change, land use, biogeochemistry, hydrology, demography and health, this approach is an ongoing process and has been improved year-by-year as a result of contributions from various research groups that have been working with climate change. Despite its strategic nature, this approach sometimes has being applied at the operational level to evaluate *ex-ante* potential impacts of big projects (Yang, 2016); (OECD, 2010).

RIA is adopted by research organizations, and especially applied for public agricultural research organizations as a way to demonstrate economic balance resulting in financial investments in research and its positive return in terms of impact to GDP or local aggregated income, positive impacts to increase productivity and respectively economic gains for producers. This approach has been based on other derivative approaches that have included social and environmental dimensions. LCSA is a typical operational and detailed process for evaluating projects with high potentiality of environmental and social impacts. Specifically to assess project impacts, usually generating data that allows producing energy balance, carbon balance, viewing all stages or processes inherent to any project, product or service. This approach is very interesting for detailing SEI and/or EIA.

Focusing impact assessment discussion to agricultural research and innovation institutions, it is interesting to make a synthesized analysis of three public organizations that generate technological solutions for farmers and agricultural supply-chains: INRA, CIRAD and Embrapa.

Impact Analysis of the Public Agronomic Research - ASIRPA is highly based in RIA, this approach has been used in the National Agronomical Research Institute of France (INRA). It strongly has an agronomical and economic impact. It has been important to demonstrate effectiveness and effects to producers, supply-chain and GDP aiming economic sustainability for the research institution. It represents an important feedback for policies and strategies adjustments and to renew research priorities, but it would be interesting to set a clear pathway for reach efficacy on this feedback mechanism. Moreover, there is an interesting organizational unit in INRA, it is the Ethical Advisory Commitee for Agronomique Research. This Commitee makes analysis of public agronomic research impact and provides information to the ASIRPA system, as well as, feed the management upper about research internal profitability (INRA & CIRAD, 2016). Finally, the approach needs to incorporate a stronger emphasis on the social and environmental dimensions and enfold stakeholders in the evaluation process.

Adopted by CIRAD, IMPact of RESearch in the South - IMPRESS is an approach similar to RIA, but with visible advances in incorporate social and environmental dimensions and also by hearing stakeholders. The conceptual approach is very interesting by creating expectation to link strategic and operational levels but, after case studies, results seems to reduce reflexes or feedbacks only to the operational level and it is not clear how it will connect results to the strategic level with effective impact to research priorities by using feedback mechanisms. The impact pathways is one crucial aspect emphasized by this approach, because it allows the identification of barriers and positive points with more facilities along the impact route, through its short, medium or long-term, as well as, with direct or indirect effects.

Brazilian Agricultural Research Corporation – EMBRAPA, each year, produces a Social Report that is a strategic report directed for stakeholders, Federal government court of accounts and for society in general, which adopts a method to aggregate and synthesize information in a institutional document by sampling of the three technological solutions generated by each one of its 41 research centers, and demonstrate effects of their technologies to supply-chain, farmers, local and national population direct or indirect affected for produced technologies, and also, reflexes for Gross Domestic Product (GDP) by rating of return estimation. The Ambitec-Agro (Integrated Impact Assessment) is an operational methodology that feed of data and information the Social Report elaboration by an aggregation process of information, aiming generates a strategic profile document (Rodrigues, 2015). Ambitec is a deep and detailed socio-environmental and economic assessment from each technology chosen, within sampling. This method plunges towards technologies impact analysis, with emphasis to environment component, although it includes the social and economic dimensions

Because the methodology has a wide spectrum in order to become adaptable to different types of agricultural technologies (for instance: prototypes, methods, processes, genetic material, animal semen, seeds, and other biotechnologies), it requires that local applicability respect the learning process of each involved research team, in accordance with each technology specificity, including complexities of ecological environment, characteristics of the farm and the production system adopted (Rodrigues, 2015).

The Ambitec-Agro system has been used as a tool to support the institutional management of agricultural research, as a document of accountability to the federal government (main agricultural research funder) and is a way of transparency for the society. In addition, it shows itself as an instrument for researchers to analyze the relevance of their scientific and technological contributions, and to define new priorities for research. The Ambitec allows evaluating several occurrences of negative or positive environmental indices that provoke impacts from the use of certain agricultural technology. For instance, plant and animal genetic improvement technologies effects are measured by basing on increased demand for inputs related to area extension, resulting in their potential negative (due to increase inputs use) or positive environmental impacts (when reduce agricultural areas due to intensification and productivity increased). Another identified aspect in this methodology are the parameters adopted for the agro-industrial and post-harvest technologies evaluation, according to demand levels for energy and inputs, which tend to generate negative environmental impacts in case of increasing or positive when reduction of these demands occurs . More, indicators were constructed based on criteria of technology impacts that can have environmental aspects as: quality of soil, quality of water, biodiversity, environmental recovery, atmosphere, use of inputs. Socio-economic aspects as: employment opportunities, income generation, quality and work conditions, food security, safety and health at work, productive ethic, institutional relation and other points (Rodrigues, 2015).

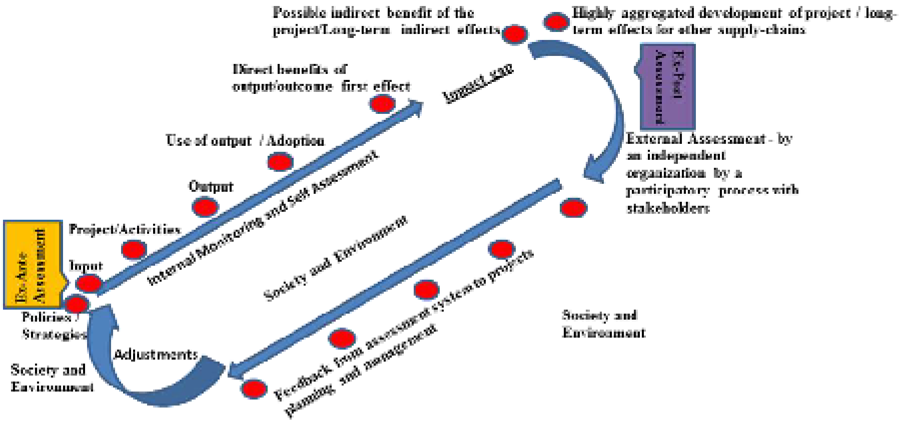
Approach indicates that some technologies can generate effects for many years, considering features of agricultural technologies and its biological, ecological, social and economic components. Recently, this approach regards aspects related to operational management while technologies are adopted and feed the Social Report, that is a strategic document. Despite its great advances if comparing with other methodologies, this approach could be improved if it could adopt the CIRAD experience for emphasizing impact pathways, as considered in IMPRESS methodology and regarding a wider approach of sustainable landscape indicators by a greater spatial and systemic view. Also, it could consider consumers through its analysis as a vital component of the supply-chain, that would become a more complex process, but indeed, challenging. In addition, Embrapa data and information resulted of its methodology could be an interesting input to Sustainability Report - GRI elaboration as part of a general assessment system (GRI, 2017).

Sustainability Report (SR) denotes a type of report that demonstrates to stakeholders the organization sustainability performance. Really ideal point would be to show negative and positive results found, but, generally SR, only demonstrates positive aspects. SR, according to GRI guide, suggests that organizations have to show the reality of the impact (positive and/or negative), which normally does not happen. SR based on GRI aims to demonstrate a transversal approach on impact sustainability and governance performance, well advanced in terms of multidisciplinarity and integrality report for the strategic level. Reports could be an opportunity for a strategic document aiming to promote adjustments on organizational policies and guidelines (as GRI suggests for reports construction), however, in practice several reports have been good merchandizing documents. According to the Global Reporting Initiative – GRI, sustainability reporting has being widely applied in private companies but, in the public sector it could be more adopted by institutions. It recommends this reporting standard as an important instrument to governments and market regulators in their policy for helping them to guarantee transparency and comparability among businesses, stakeholders and society (GRI, 2010). In fact, SR represents an important opportunity for public organizations, meantime, it would require that GRI guide adapts its language and structure for the public sector.

By analyzing impact assessment experiences, concepts and approaches and confronting it to a transversal, holistic and transdisciplinary perspective it is unavoidable to understand that would be necessary a governance and managerial system to see a complete process that begins at policy and planning stage, pass by tactical level and reach to operational which will generate products and services to be delivery to supply-chain and consumers, affecting microeconomic environments, with greater or lesser effects to macroeconomic, and impacting ecological environment more or less by different scales. To meet this expectation the Transition Management (Loorbach & Rotmans, 2010) and Sustainability Transition (Markard et al, 2012) approaches express important contributions to be recovered for a more complete and integrated approach of sustainability impact assessment applicable for agricultural research institutions or any kind of organization.

Through a governance and managerial perspective, an impact system can be seen (see Figure 1 – General Impact System), where society's needs or demands plus environment requirements for its resilience can be identified . Both components will enable to capture data and to process information for planning and management orientation. Process will start with inputs, included policies/strategic orientations that will set bases for implementing projects and activities, next step are the outputs, then, comes the adoption of outputs, and finally outcomes with their respective impacts to society and environment. There is usually a time gap between direct and indirect impacts, with the possibility of diffuse effects on the environment, productive chains and society. This impact assessment system will supply information to innovation plan adjustments. Thus, with formulated policies/strategies/projects it will be possible to make a confrontation between ex-ante predicted impact (impact plan) with ex-post impacts (policies/projects and activities accomplished). The proposed system drives for a new wider approach which allows analyzing hypothetical steps, before begin a new policy or project until their performance.

Environmental Management and Sustainable Development
ISSN 2164-7682
2017, Vol. 6, No. 2



Source: Adapted from GTZ Impact Model (Kuby, 1999)

Figure 1. General impact system-by impact pathway approach

This system (above) resulted from the combination of Douthwaite (2003) and Kuby (1999) theories, which, also, afford to view impact pathways - interrelation between begining versus end of a project and their effects for short and long-term, as well as, showing integration internal and external ambience with self monitoring/evaluation and stakeholders by a participatory assessment process (Barret, 2015). It is recommended that, besides monitoring and *ex-ante* impact assessment by organization itself, the *ex-post* assessment can be done by independent organization (Douthwaite, 2003).

This analysis drives us to enlarge our thought towards innovation processes that is perfectly aligned with our goal of analyzing impacts of research organization. After all, the main role of a research organization is not to search for mere scientific curiosity but for innovation. Then, recovering innovation concepts we will make a brief contextualization. Into economic mainstream, the oldest theoretician of innovation, Schumpeter (1983), defined it: as new material and force combination that discontinuously arises, generating new goods which consumers are not used to; a new production method; the opening of a new market; conquest of a new supply of raw materials or semi-manufactured goods; breeding of a new productive organization. The latest version of the Oslo Manual, in 2005, set innovation categories: product innovation, process innovation, organizational innovation and marketing innovation as aspects of innovation approaches (Insee, 2016).

"Innovation is the process of making changes to something established by introducing something new" (O'Sullivan, 2009). An innovation can means something completely new or represents just a small increment, and it can be applied to products, processes or services. (O'Sullivan, 2009). It is basic that invention can reach to the market, however, it is not enough, it demands a feedback loop and deep relationship to society's needs, with following up its needs and desires, with unremitting dialogue between organization and society (Planing, 2017). Disruption innovation is another reading for innovation, which forecast that when a new actor enters to the market and frontally beats on competitors, offering better products or services, the oldest ones will try to innovate to defend their businesses (Christensen, 2015). Presently, open innovation has been the most modern trend for innovation approach, especially due our complex and dynamic information world which requires other organizational designs for innovation. Open innovation has been defined as "… the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesbrough et al., 2006). As we can see, innovation that represents a key role of research organizations is directly connected to necessary systems of impact assessment.

An organization, especially of the agricultural research sector, for improving and increasing its innovation process must assess the impact of all its solutions to farmers, supply-chain and society, as well as, have to evaluate impacts to the environment resulted from its technologies, products and services. In regard to the holistic and transdisciplinary perspective it would be important to consider the prism for innovation, videlicet, social innovations which means solutions (e.g.: technologies, products, services, processes) that meet social needs, with effective and positive impact to society, which promote social empowerment and can provide better quality of life (Pisano et al, 2015).

New practices often require new paradigms and desertion of ongoing practices that will happen only when decision-makers recognize a simple truth: "Sustainability = Innovation" (Nidumolu, 2009). "A major target of the SDG agenda is the eradication of hunger" (FAO et al, 2015), the, world increasingly demands food production, and well nourished people, now and to the future, requiring agricultural productivity by using sustainable solutions (FAO et al, 2015). Thereby, agricultural research organizations have an important role to generate increasingly sustainable technologies, products, processes and services that will be measured by managerial systems of impact assessment.

Nowadays trends indicate fragmented approaches towards integrated, holistic and transdisciplinary approach. Economic, social or environmental impact assessment is not more viable by dissociated analysis. An innovation discussion approaches the same trend, which means, sustainability innovation rather than separate social innovation, or economic or environmental innovation.

Based on previous conceptual stage and discussions an analytical synthesis demonstrated several approaches related to impact assessment, considered in this paper, as follows (Table 1). It is important to consider that this synthesis represents what is usually adopted in methodological terms and on field.

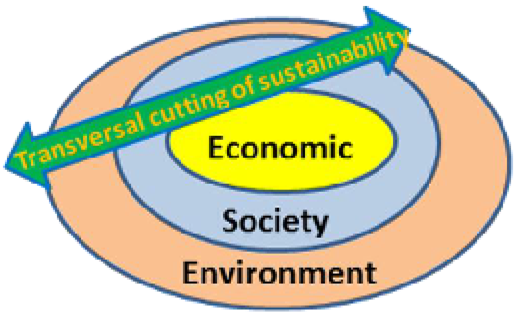
Table 1. Impact Assessment Approaches - Analytical Synthesis

Approach	Application Scale (Strategic / Tactical / Operational)	Timing of Application (Ex-Ante / Ex-Post)	Systematic Connection between Innovation System and/or Policies/Projects with *Ex-Ante* plus *Ex-Post* Impact Assessment?
Economic Impact – EI	Operational (projects)	Both	No
Social Impact – SI	Operational (projects)	Ex-Ante	No
Social-Economic Impact – SEI	Operational (projects)	Ex-Ante	No
Health Impact Assessment – HIA	Operational (projects)	Ex-Ante	Partially
Environment Impact Assessment - EIA	Operational (projects)	Ex-Ante	No
Strategic Environment Impact – SEA	Strategic (policies, plans, programs)	Ex-Ante	No
Sustainable Impact Assessment – SIA	Strategic (policies, plans, programs)	Ex-Ante	No
Integrated Assessment – IA (TBL=Three Bottom-Line)	Operational (projects)	Ex-Ante	No
Integrated Assessment and Modeling – IAM	Strategic/Operational (plans, programs, projects)	Ex-Ante	No
Research Impact Assessment – RIA	Operational (projects, technologies, products, services)	Ex-Post	No
Life Cycle Sustainability Assessment – LCSA	Operational (projects, activities)	Ex-Ante	No
Impact Analysis of the Public Agronomic Research - ASIRPA	Operational (projects, technologies)	Ex-Post	No
IMPact of RESearch in the South -IMPRESS	Operational (projects, technologies)	Ex-Post	No
Social Report / Ambitec-Agro (Integrated Impact Assessment)	Strategic/Operational (projects, technologies, products, services)	Ex-Post	Partially
Sustainability Report (SR)	Strategic/Operational (plans, programs, projects, general actions and activities)	Ex-Post	No

5. Conclusion and Suggestion for Future Researches

Organizations implement policies, plans, programs, projects and activities, and generate products and services. Then, organizations generate impacts and conflicts of interest. All these conflicts and impacts can be well governed and managed if organizations create consistent systems of impact assessment. As a consequence, organizations that are more sustainable in their processes, products and services will propitiate a more sustainable world. Organizations can help their personnel to construct more sustainable attitudes that can be disseminated to their families, friends and others. The complexity of the theme and the interweaving of social, environmental and economic components require an essentially holistic and transdisciplinary vision, demanding more extensive creation for integrative methodologies on impact assessment under sustainability perspective and using a transversal cut for analysis. Few methodologies and experiences have demonstrating balance among all dimensions, and, in general, have been adopting methods or practices with bias by emphasizing one aspect in prejudice of another one.

Below, Figure 2, can demonstrate how a transversal perspective set each dimension into its appropriate scale inasmuch as: economic environment is part of society which is structured by organizations and experts who integrate the social environment; society is inserted into the local, national and international space which is into the planet; thus, the planet and the environment represent the biggest space or ambience where society and the economy are, respectively, inset. It is a basic mathematic question: the smallest universe is within the larger one. This interrelationship does not means that one is more important than another, but despite equal ponderosity it is concrete that if environment is not protected, the society will suffer consequences and the economic environment will be deteriorated. The economic system to survive has to create sustainable instruments and mechanisms for society to support itself with quality of life on an equitable social structure, as well as, to provide quality of life today and for future society it has to conserve environment in resilient balance.



Source: Reprinted (Adapted) on Cato (2009)

Figure 2. Integrated and transversal view for sustainability

Suitable methodologies need to be constructed through an integrated, transversal, holistic and transdisciplinary perspective, using high participatory stakeholder process (including consumers, as last stage of chain). Ethical attitudes for data and information collecting and for report elaboration are needed, while demonstrating positive and negative, realities, displaying transparence for society from their products, processes and service impacts. Presently, assessment approaches are fragmented by *ex-ante* or *ex-post* analysis, focusing emphatically environmental, social or economic dimensions. For the future, a new methodology could be based on a general model that could stimulate balance among all dimensions. This new perspective implies the review of the concept of impact assessment by a complete process, including *ex-ante* and *ex-post* as part of a whole managerial assessment system. Surely, balanced reports can be much more useful for strategic, tactical and operational decision-making processes, adjusting plans, improving programs, processes, projects, products and services toward a more sustainable production.

Thus, we recommend for next researches: 1. a deeper comparative analysis on sustainability impact assessment among agricultural research organizations by a holistic, transdisciplinary and transversal perspective; 2. propose improvement to existed impact assessment approaches, including proposition of sustainability impact assessment model for technological agricultural innovations by combining several methodologies such as SR based on GRI, Integrated Impact Assessment TBL according to Embrapa, CIRAD and other institution's experiences. Transition Management and Sustainability Transition could be timely approached to base a governance-managerial platform for supporting the proposed model and future system of sustainability impact assessment of agricultural research organizations; 3. to test and validate (in field) the proposed governance-managerial model for sustainability impact assessment of agricultural technological solutions.

Acknowledgement

The research is financed by IRD and Embrapa. I am grateful for Prof. Helen Gurgel, University of Brasilia.

References

Alston, J. M., Norton, G. W., & Pardy, P. G. (1995). Science Under Scarcity: Principles and Practices for Agricultural Research Evaluation and Priority Setting (1st ed.). Cornell University Press and ISNAR, Ithaca, New York, USA, 105-107, 493

Asif, M., Searcy, C., Zutshi, A., & Ahmad, N. (2011). An integrated management systems approach to corporate sustainability. *European Business Review, 23*(4), 353-367. https://doi.org/10.1108/09555341111145744

Bantilan, Cynthia, Templeton, Debbie & Craswell, Eric. (2014). Concepts and Tools for Agricultural Research Evaluation and Impact Assessment - Report on Master Class on Impact Assessment International. Edited by Crops Research Institute for the Semi-Arid Tropics,

Patancheru, A. P. (2009). India 18-27 March, Available: https://www.crawfordfund.org/wp-content/uploads/2014/03/Impact_assesment_Masterclass.pdf.

Barret, D., Clavel, D., Dabat, M-H., Faure, G., Mathé, S., Temple, L., Toillier, A., &

Triomphe, B. (2015). Impress - Guide méthodologique sur l'évaluation des impacts de la recherche agronomique dédiée aux pays du sud. Centre de coopération internationale en recherche agronomique pour le développemen-Cirad. Available: http://impress-impact-recherche.cirad.fr/

Becker, Henk A. (2001). Social impact assessment. *European Journal of Operational Research*, *128*, 311-321. https://doi.org/10.1016/S0377-2217(00)00074-6

Becker, Henk A., & Vanclay, Frank. (2003).The International Handbook of Social Impact Assessment: conceptual and methodological advances. ISBN-10: 1840649356, Edward Elgar Publishing Limited, illustrated edition, 4-12, 129-142. https://doi.org/10.4337/9781843768616

Bond, Alan, J., & Morrison-Saunders, Angus. (2011). Re-evaluating Sustainability Assessment: Aligning the vision and the practice. *Environmental Impact Assessment Review*, *31*, 1-7. https://doi.org/10.1016/j.eiar.2010.01.007

Cato, Molly Scott. (2009). Green Economics: An Introduction to Theory, Policy and Practice, pp. 37. First published by Earthscan. London, UK. Available: http://www.gci.org.uk/Documents/128075741-Green-Economics-an-Introduction-to-Theory-Policy-and-Practice.pdf

Convention on Biological Diversity - CBD. (2006). The voluntary guidelines for biodiversity-inclusive impact assessment, adopted through decision VIII/28. Available: https://www.cbd.int/doc/publications/imp-bio-eia-and-sea.pdf

CGIAR, About Us. (2017). Official Site. Available: www.cgiar.org

Chesbrough, H. W., West, J., & Vanhaverbeke, W. (2006). Open Innovation: Researching a New Paradigm, pp. 21-94, ISBN: 9780199226467. Oxford: Oxford University Press, Oxford, UK

Chowdhury, Dhiman Deb. (2013). Organizational Citizenship Behavior Towards Sustainability. International Journal of Management, *Economics and Social Sciences*, *2*(1), 28-53.

Cohen, E., & Lloyd, S. (2014). Disciplinary evolution and the rise of the transdiscipline. Informing Science: the International Journal of an Emerging Transdiscipline, 17,189-215. Online ISSN: 1521-4672, Print ISSN: 1547-9684. Available: https://www.informingscience.org/Publications/2045?Search=Transdiscipline

Colinet, Laurence ; Joly, Pierre Benoit ; Gaunand, Ariane ; Matt, Mireille ; Laredo, Philippe, et al.. (2014). ASIRPA - Analyse des Impacts de la Recherche Publique Agronomique. Rapport final.[Rapport de recherche] Institut National de la Recherche Agronomique. 2014, 61 p.<hal-01190008>. Available : https://hal.archives-ouvertes.fr/hal-01190008/document

Christensen, Clayton, M., Raynor, Michael, E., & McDonald, Rory. (2015). What is disruptive innovation? Harvard Business Review, December, 2015. Available: https://hbr.org/2015/12/what-is-disruptive-innovation

Delmottea, Sylvestre, Lopez-Ridauraa, Santiago, Barbiera, Jean-Marc, Weryb, Jacques. (2013). Prospective and participatory integrated assessment of agricultural systems from farm to regional scales: Comparison of three modeling approaches. *Journal of Environmental Management, 129*, 493-502. https://doi.org/10.1016/j.jenvman.2013.08.001

De Smedt, Peter. (2010). The use of impact assessment tools to support sustainable policy objectives in Europe. *Ecology and Society, 15*(4), 30.
https://doi.org/10.5751/es-03623-150430

Douthwaitea, Boru, Kubyb, Thomas, Fliertc, Elske van de & Schulzd, Steffen. (2003). Impact pathway evaluation: an approach for achieving and attributing impact in complex systems. *Agricultural Systems, 78*, 243-265. https://doi.org/10.1016/S0308-521X(03)00128-8

Eccleston, Charles H. (2011). Environmental Impact Assessment: A Guide to Best Professional Practices. CRC Press Taylor & Francis Group. https://doi.org/10.1201/b10717

Empresa Brasileira de Pesquisa Agropecuaria – Embrapa. (2017). Gestão Estratégica -Embrapa gera impactos efetivos para a sociedade brasileira. Available:
https://www.embrapa.br/group/intranet/busca-de-noticias/-/noticia/21885057/embrapa-gera-impactos-efetivos-para-a-sociedade-brasileira

ERCHP – European Centre for Health Policy. (1999). Gothenburg Consensus Paper - Health Impact Assessment: main concepts and suggested approach. World Health Organization – WHO Regional Office for Europe, 1999. Available:
http://www.impactsante.ch/pdf/HIA_Gothenburg_consensus_paper_1999

European Environmental Agency (EEA) (2001). Participatory Integrated Assessment methods: an assessment of their usefulness for the European Environmental Agency. Technical Report 64, Copenhagen. Available:
http://www.pedz.uni-mannheim.de/daten/edz-bn/eua/01/tech64.pdf

Ewert, F., Rötter, R. P., Bindi, Webber, M., Trnka, H.,M., Kersebaum, K. C., … Bartošová, L. (2015). Crop modelling for integrated assessment of risk to food production from climate change. Environmental Modelling & Software. *Elsevier, 72*, 287-303.
https://doi.org/10.1016/j.envsoft.2014.12.003

FAO – Food and Agricultural. (2012). Environmental Impact Assessment (EIA): Guidelines for FAO Field Projects, ISBN 978-92-5-107276-9: http://www.fao.org/3/a-i2802e.pdf

-------. (2015). International Fund for Agricultural Development – IFAD; World Food Programme – WFP. Achieving Zero Hunger The critical role of investments in social protection and agriculture: http://www.fao.org/3/a-i4777e.pdf

Freeman, Joshua. (2005). Towards a definition of holism. British Journal of General Practice - *Br. J. Gen Pract, 55* (511), 154-155. Available:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1463203/

Freudenburg, William R. Social Impact Assessment. (1986). Annual Review of Sociology, *12*, 451-478. https://doi.org/10.1146/annurev.so.12.080186.002315

Gatherer, Derek. (2010). So what do we really mean we say that systems biology is holistic? *BMC Systems Biology, 4,* 22. Available: https://bmcsystbiol.biomedcentral.com/articles/10.1186/1752-0509-4-22

Global Report Initiative – GRI. (2017). Website, Empowering Sustainable Decisions. Available: https://www.globalreporting.org/information/sustainability-reporting/Pages/default.aspx

-------. (2010). GRI Reporting in Government Agencies. GRI ISBN number: 978-90-8866-033-7. Available: https://www.globalreporting.org/Pages/default.aspx

Gray, Barbara. (2008). Enhancing Transdisciplinary Research through Collaborative Leadership. *US National Library of Medicine - National Institutes of Health - Am J Prev Med. 35*(2 Suppl): S124-S132. https://doi.org/10.1016/j.amepre.2008.03.037

Hadorn, Gertrude Hirsch, & Pohl, Christian. (2007).Principles for Designing Transdisciplinary Research. ISBN-13: 978-3-86581-046-5, Oekon 1st Edition, p. 3-42 Munich (Germany).

Harris, G. (2002). Integrated assessment and modeling – science for sustainability. R. Costanza, S. E. Joergensen (Eds.), Understanding and Solving Environmental Problems in the 21st Century, Elsevier, 5-17. https://doi.org/10.1016/b978-008044111-5/50003-2

Impact Assessment Institute – IAI / The Institute for Impact Assessment and Scientific Evaluation of Policy and Legislation. (2017). IAI Website, About the Impact Assessment Institute, definition specified at the second paragraph. Available: http://www.impactassessmentinstitute.org/about

INRA – Science & Impact and CIRAD. (2016). Comité consultatif commun d'éthique pour la recherche agronomique. Avis 9 sur les enjeux éthiques de l'évaluation des impacts de la recherche publique agronomique. Available: https://inra-dam-front-resources-cdn.brainsonic.com/ressources/afile/347600-2f44f-resource-avis-9-du-comite-d-ethique.pdf

International School on Research Impact Assessment – ISRIA. (2017). Available: http://theinternationalschoolonria.com/

ISO – International Organization for Standardization. (2015). Introduction to ISO 14001- Available: https://www.iso.org/files/live/sites/isoorg/files/archive/pdf/en/introduction_to_iso_14001.pdf

Joly, P. et al. (2016). Agricultural research impact assessment: Issues, methods and challenges, *OECD Food, Agriculture and Fisheries Papers*, https://doi.org/10.1787/5339e165-en

Kuby, T. (1999). Innovation as a Social Process: What Does this Mean for Impact Assessment in Agricultural Research. Paper presented at a CIAT workshop, Costa Rica, September 1999.

Loorbach, Derk, & Rotmans, Jan. (2010). The practice of transition management: Examples and lessons from four distinct cases. *Futures, 42*, 237-246.

https://doi.org/10.1016/j.futures.2009.11.009

Markard, Jochen, Raven, Rob, & Truffer, Bernhard. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research Policy, 41*(6), 955-967. https://doi.org/10.1016/j.respol.2012.02.013

MasterQResearch. (2012). Socio-Economic Impact Assessment as part of the Environmental Impact Assessment Process for the Proposed Thyspunt Lines Integration Project DWEA Ref. No. 12/12/20/1212: Northern Corridor - The construction and operation of 3x 400kV transmission power lines: 1x Thyspunt Grassridge and 2x Thyspunt – Dedisa, South Africa, Dec 2010. Available:
http://www.eskom.co.za/OurCompany/SustainableDevelopment/EnvironmentalImpactAssessments/Documents/EIA_SIA_Report_NC_Rev_1.pdf

Merrey, D. J. (2015). An Evaluation of CGIAR Centers' Impact Assessment Work on Irrigation and Water Management Research. Rome, Italy, Standing Panel on Impact Assessment (SPIA), CGIAR Independent Science and Partnership Council (ISPC). 83 pp. Available: http://impact.cgiar.org/evaluation-cgiar-centers-impact-0

Mitrany, Michal, & Stokols, Daniel. (2005). Gauging the Transdisciplinary Qualities and Outcomes of Doctoral Training Programs. *Journal of Planning Education and Research, 24*, 437-449. https://doi.org/10.1177/0739456X04270368

Morin, Edgar. (1990). Science avec conscience, Paris: Edition Seuil, pp 36-38.

-----------------et Le Moigne, Jean-Louis. (2003). L'intelligence de la complexité. Ed. L'Harmallan, France. EAN13: 9782738480859.

National Institute of Statistics and Economics Studies of France - INSEE. (2016). Available: https://www.insee.fr/en/metadonnees/definition/c1182

NCVO - The National Council for Voluntary Organisations, England. (2017). Written by Dr Richard Piper. Available :
https://knowhownonprofit.org/organisation/impact/about-impact-and-evaluation/understanding-the-language. Published in 02/2017

Nidumolu, Ram, Prahalad, C. K., & Rangaswami, M. R. (2009). Why Sustainability Is Now the Key Driver of Innovation. Harvard Business Review, September 2009: Available: https://hbr.org/2009/09/why-sustainability-is-now-the-key-driver-of-innovation

Organisation for Economic Co-Operation and Development – OECD. (2010). Guidance on Sustainability Impact Assessment. 2010 edition. Available:
http://www.oecd.org/greengrowth/48305527.pdf

O'Sullivan, D. (2009). Applying Innovation. Sage Publishing, Thousand Oaks 1st Ed., California, pp 3.

Oxford Economics. (2013).The economic impact of Starbucks on the UK economy. A report for Starbucks. Available: http://www.oxfordeconomics.com/my-oxford/projects/278163

-------- (2015).The impact of BAE systems on the UK economy. Available: http://www.oxfordeconomics.com/my-oxford/projects/311905

Piaget, Jean. (1972). Epistemologie des relations interdisciplinaires. In: CERI (EDS.) L'interdisciplinarité. Problèmes d´enseignement et de recherche dans les Universités, p. 131-144. Paris: UNESCO/OCDE.

Pisano, Umberto; Lange, Lisa, & Berger, Gerald. (2015). Social Innovation in Europe An overview of the concept of social innovation in the context of European initiatives and practices. ESDN Quarterly Report.

Planing, Patrick. (2017). On the origin of innovations-the opportunity vacuum as a conceptual model for the explanation of innovation. *Journal of Innovation and Entrepreneurship, 6*, 5. https://doi.org/10.1186/s13731-017-0063-2

Popa, Florin; Guillermin, Mathieu, & Dedeurwaerdere, Tom. (2015). A pragmatist approach to transdisciplinarity in sustainability research: From complex systems theory to reflexive science. *Futures, 65*, 45-56, https://doi.org/10.1016/j.futures.2014.02.002

Pope, Jenny; Annandale, David and Morrison-Saunders, Angus. (2004). Conceptualising sustainability assessment. *Environmental Impact Assessment Review, 24,* 595-616. https://doi.org/10.1016/j.eiar.2004.03.001

Rodrigues, Geraldo Stachetti, Buschinelli, Cláudio and Avila, Antonio Flavio. (2010). An Environmental Impact Assessment System for Agricultural Research and Development II: Institutional Learning Experience at Embrapa. *Journal of Technology Management & Innovation J. Technol. Manag. Innov., 5*(4), 38-56. https://doi.org/10.4067/S0718-27242010000400004

Rodrigues, Geraldo Stachetti.(2015). *Avaliaçao de Impactos Socioambientais de Tecnologias na Embrapa*. Publication Embrapa Documentos, 99.

Roquete, Fátima; Amorim, Maria, Barbosa, Simone, Souza, Danielle, Carvalho, Vilma. R. Enferm. (2012). Dialogue among knowledge: multidisciplinarity, interdisciplinarity and transdisciplinarity in public health field. *Cent. O. Min. set/dec, 2*(2), 463-474.

Ruegg, R. & Feller, I. (2003). *A Toolkit for Evaluating Public R&D Investment: Models, Methods, and Findings from ATP's First Decade.*, Gaithersburg: National Institute of Standards and Technology.

Sadler, Barry and Dalal-Clayton, Barry. (1999). Strategic Environmental Assessment: A Rapidly Evolving Approach, ISBN: 1 904035 33 7.IIED, London. Available: http://pubs.iied.org/pdfs/7790IIED.pdf

Scholz, R.W.; Mieg, H.A.; Oswald, J.E. (2000). Transdisciplinarity in groundwater management – Towards mutual learning of science and society. *Water, Air, & Soil Pollution, 123*(1-4), 477-487. https://doi.org/10.1023/A:1005292328778

SCHUMPETER, J. A. The theory of economic development. (1983). Transaction Publishers, New Brunswick, New Jersey, USA, pp. 112-160. Original material copyright 1934 by the President and Fellows of Harvard College. ISBN: 978-0-87855-698-4.

The Review Board. (2007). Socio-Economic Impact Assessment Guidelines. Mackenzie Valley Environmental Impact Review Board: Available: http://www.reviewboard.ca/upload/ref_library/SEIA_Guidelines_Contents_and_Chapter_1.pdf

UN – United Nations. (1987). Our Common Future Report, March 1987. Available: http://www.un-documents.net/our-common-future.pdf

---------. (1992). Agenda 21, Item 8.3 – Sustainable Development. United Nations Conference on Environment & Development Rio de Janerio, Brazil, 3 to 14 June 1992. Available: https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf

---------. (2012). Realizing the Future We Want for All, Report the Secretary-General, (A/CONF.216/1.1) New York, paragraph 252. For the complete report, please check: Available: http://www.un.org/en/development/desa/policy/untaskteam_undf/report.shtml

--------.(2015). Transforming our world: the 2030 Agenda for Sustainable Development. General Assembly. Resolution adopted by the General Assembly on 25 September 2015 (seventieth session), http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

United Nations Environment Programme - UNEP. (2004). Environmental Impact Assessment and Strategic Environmental Assessment: Towards an Integrated Approach. Edited and published by UNEP, Geneva. Available: http://unep.ch/etu/publications/textONUBr.pdf

--------/SETAC. (2011).Towards a life cycle sustainability assessment: Making informed choices on products. Life Cycle Initiative. ISBN: 978-92-807-3175-0, Job Number: DTI/1412/PA. Available: http://www.unep.fr/shared/publications/pdf/DTIx1412xPA-Towards%20a%20LCSAMakingInformedChoice.pdf

Verheem, R. (2002). Recommendations for Sustainability Assessment in the Netherlands. In Commission for EIA. Environmental Impact Assessment in the Netherlands. Views from the Commission for EIA in 2002. The Netherlands. Available: https://www.researchgate.net/publication/267399927_Experiences_on_Sustainability_Assessment_in_the_Netherlands

Wernham, Aaron. (2011). Health Impact Assessments Are Needed In Decision Making About Environmental And Land-Use Policy. *Health Aff, 30*, 5947-956. https://doi.org/10.1377/hlthaff.2011.0050

Yang, Zili, Wei, Yi-Ming, & Mi, Zhifu. (2016). Integrated Assessment Models (IAMs) for Climate Change. *Oxford Bibliographies Online. LAST MODIFIED*, 28. https://doi.org/10.1093/obo/9780199363445-0043

Copyright Disclaimer

Annex 6 : Résumé de thèse en français

Modèle conceptuel d'évaluation d'impact de l'innovation - basé sur des études de cas d´ organisations de recherche agricole en France, au Brésil et en Australie

Contextualisation générale

Qu´en est-t-il de la durabilité agricole dans le monde, des objectifs de développement durable, ainsi que des défis et problèmes liés à l'impact de la recherche en agriculture ?

Le monde passe par des changements rapides et novateurs dans tous les domaines de la société. Les transformations technologiques, économiques, sociales et environnementales ont amené les Nations Unies - l'ONU - à jouer un rôle de premier plan dans les discussions, les accords et les définitions politiques mondiaux en vue d'un développement chaque fois plus durable. Dans ce contexte, l'ONU a lancé 17 objectifs de développement durable (ODD) qui devront être mis en œuvre d'ici 2030 (ONU, 2015).

Parmi ces objectifs, le SDG 2 stipule que la faim et la malnutrition devront être éliminées grâce à l´agriculture durable, alors que le SDG 12 traite de la consommation et de la production durables (ONU, 2015). Aussi, les organismes de recherche et d'innovation agricoles ont un rôle important à jouer dans la mise au point de technologies, de produits, de processus et de services de plus en plus durables qui devront être évalués par un système de gestion de l'évaluation de leurs impacts.

En effet, après la fin de la Seconde Guerre mondiale, le secteur agricole s'est considérablement orienté vers une augmentation de la productivité des aliments et des fibres. Cela a donné lieu à l´invention de nouvelles technologies, à la mécanisation qui ont simultanément accru l'utilisation des produits chimiques, à la sur-spécialisation et aux politiques gouvernementales ayant favorisé la croissance de la production. Tous ces facteurs ont réduit considérablement la demande en main-d'œuvre dans une grande partie des pays agricoles, comme les Etats-Unis, la France, le Canada, l'Allemagne, l'Australie, l'Argentine et le Brésil entre autres. Les risques économiques pour les agriculteurs ont été réduits, mais dans le même temps, les coûts environnementaux et sociaux ont été visibles : épuisement des sols, contamination des eaux souterraines, réduction de l'emploi dans les zones rurales, spoliation des terres, expansion des villes etc... Dans de nombreux pays, l'agriculture familiale a presque disparu et dans d'autres, elle s'est retrouvée en dehors du processus productif majeur de l'agrobusiness mondial, et avec l'expansion de l'échelle de production, les pratiques agroécologiques ont également été réduites (Feenstra, 2018).

Bien que l'agriculture ait subi un intense processus de modernisation au cours des soixante-dix (70) dernières années, il reste encore beaucoup à faire. Cependant, plus de responsabilité sociale et environnementale est requise. Selon la FAO, d'ici 2050, la population atteindra 9,8 milliards d'habitants, soit 29% de plus que le nombre actuel et la croissance la plus forte se situera dans les pays en développement. Soixante-dix pour cent 70% de la population sera urbaine et les niveaux de revenu seront plus élevés que ceux actuels. Pour nourrir cette population plus nombreuse, plus urbanisée et plus riche, la production alimentaire devrait augmenter de 70%. La production céréalière devra passer de 2,5 milliards de tonnes produites aujourd'hui à 3 milliards de tonnes/an. La production de viande devra augmenter de plus de 200 millions de tonnes. Dans cette perspective, il faudrait repenser la façon de produire en utilisant des solutions durables pour les agriculteurs et toute la chaîne d'approvisionnement (FAO, 2017).

De nos jours, une grande partie de l'expérience acquise par les organismes de recherche montre encore des approches fragmentées. L'agriculture de l'avenir doit permettre plus d'inclusion sociale et productive dans les zones rurales pour éviter le processus d'exode rural ayant affecté de nombreux pays dans le monde. En même temps, elle doit assurer la sécurité alimentaire pour les populations locales et mondiales, ainsi que fournir des aliments sains pour la santé humaine, en plus de la nécessité d'utiliser des solutions qui respectent les limites de l'environnement et sa nécessaire résilience. Nous avons donc besoin de technologies innovantes dans une perspective de durabilité vers une approche intégrée, holistique, constructiviste et transdisciplinaire du processus d'innovation, tout en évitant les lacunes dans une perspective de durabilité (Asif et al., 2011 ; Becker, 2001 ; Joly, P. et al., 2016 ; Cato, 2009).

Dans cette optique, il est fondamental d'identifier les moyens d'aider les organismes de recherche agricole à améliorer la performance de leurs processus d'innovation en mettant l'accent sur une production technologique toujours plus durable (Feenstra, 2018). Par conséquent, l'évaluation de l'impact de l'innovation devient une étape cruciale pour pouvoir adapter les politiques, la gestion de la recherche, le leadership des projets de recherche et le développement d'une culture d'impact organisationnelle étendue aux parties prenantes. A titre d'exemple, l'un des principaux facteurs limitants est la consommation d'eau, en raison de la crise hydrique croissante (Grey et al., 2015 ; Saito, 2017).

Au cours des quarante (40) dernières années, les institutions de recherche ont amélioré leurs systèmes d'évaluation de l'impact de l'innovation afin de démontrer, aux gouvernements et à la société, l'importance de la recherche. Plusieurs organismes de recherche de pointe du monde entier se sont donc penchés sur la question de l'évaluation de l'impact de l'innovation et sur ce qu'ils produisent considérés comme mesure essentielle pour améliorer leurs politiques, leurs stratégies, leurs projets et leurs activités et pour accomplir ainsi leurs missions institutionnelles. Les systèmes d'évaluation de l'impact de l'innovation sont essentiels pour mesurer l'effet des activités, des produits, des innovations technologiques, des processus et des services d'une organisation (Asif et al., 2011).

Il est fondamental d'évaluer comment ils atteignent et influencent leurs clients ou publics cibles, comment ils affectent l'économie de l'organisation, les chaînes de production, et aussi le nombre d'avantages qu'ils peuvent créer. Il est important d'évaluer le niveau de gravité des impacts et la mesure dans laquelle ils affectent l'écologie et la qualité de vie de l'environnement social. Il est primordial que les effets positifs et négatifs soient évalués que cela soit pour la santé de l'organisation, pour la société et pour l'environnement (Asif et al., 2011).

Après quelques analyses documentaires sur l'évaluation de l'impact sur les entreprises, et après avoir consulté certains documents de ces organismes de recherche, il est paru claire que les méthodes d'évaluation de l'impact de l'innovation mériteraient d'être approfondies. Les expériences de ces organismes de recherche ont contribué à élargir le débat sur ce thème. Toutefois, dans leurs méthodologies, certaines lacunes, qu'il conviendra d'étudier et de compléter, ont pu être observées. Par exemple, ces organismes ne considèrent pas qu'un processus de gestion global et interconnecté d'évaluation d'impact, par la visualisation des impacts *ex ante* et *ex post*, doive être évalué. Il n'a pas été observé de perception transversale de la durabilité, et il a été généralement présenté une compréhension basée sur le fait que la dimension environnementale soit plus importante que la dimension sociale, et que celle-ci soit plus importante que l'économique, respectivement, selon l'approche Cato

(2009). Après tout, l'économie est construite par la société et immergée dans l'environnement.

L'évaluation de l'impact de l'innovation, lorsqu'il s'agit d'une organisation publique, ayant un certain degré de responsabilité sociale, économique et environnementale, devrait être approfondie, car elle doit donner le bon exemple à la société et bien l´accompagner. Dans ce contexte, on sait que la plupart des organismes de recherche, y compris les organismes de recherche agricole, dépendent fortement des ressources publiques. Ainsi, évaluer l'impact de leurs recherches signifie être transparent et démontrer aux parties prenantes, aux institutions supérieures de contrôle et au gouvernement lui-même, mais surtout à la société, où et comment les ressources sont utilisées, et surtout, le niveau et la qualité de l'impact qu'elles produisent sur le secteur productif, l'économie, l'environnement et la société (Barros de Mendonca & Laques, 2017).

Néanmoins, les ressources publiques sont de plus en plus rares, surtout dans les pays où les besoins élémentaires de l´ensemble de la population sont encore loin d´être couverts. En outre, ce manque de ressources affecte considérablement les organismes de recherche et d'innovation, qui doivent de plus en plus démontrer qu'ils produisent des effets positifs pour la société et peuvent ainsi obtenir des ressources financières du gouvernement, des dons ou encore des investissements provenant de bailleurs de fonds.

Ainsi, l'objectif de cette thèse fut d'analyser les expériences d´évaluation de l'impact de l'innovation acquises par de grandes organisations de recherche agricole dans un contexte global, puis de concevoir un nouveau modèle d'évaluation de l'impact de l'innovation, comme détaillé ci-dessous :

- Élaborer une synthèse proto-conceptuelle de l'évaluation de l'impact de l'innovation ;
- Effectuer un benchmarking des procédures méthodologiques positives pour l'évaluation de l'impact de la recherche de différentes organisations reconnues sur la scène internationale comme des institutions importantes et influentes dans l´élaboration de solutions innovantes pour l'activité agricole, organisations représentant l'Amérique, l'Europe et l'Océanie ;

- Créer un modèle conceptuel d'un système d'évaluation de l'impact de l'innovation axé sur les organismes de recherche agricole et fondé sur une perspective transversale de durabilité.

En conséquence, cette thèse cherche à construire un nouveau modèle de système d'évaluation d'impact de l'innovation, basé sur une approche qui peut aider les organismes de recherche agricole à évaluer les impacts de leurs technologies, produits et services.

Ce modèle est centré sur le système d'évaluation d'impact et vise à imprimer la dimension de durabilité intégrée à leurs processus d'évaluation par une vision transversale ainsi qu'à insérer quelques principes comportementaux à considérer comme une exigence pour son succès. En tant qu'outil de gouvernance et de gestion, ce nouveau modèle devrait faciliter les processus d'innovation technologique afin qu'ils s'intègrent dans les concepts de durabilité et soient synchronisés avec le processus d'évaluation de l'impact par un système de gestion unique. On s'attend à ce que tout cela puisse aider les organismes de recherche agricole à mieux appuyer le secteur productif en fonction de la demande mondiale, en produisant des aliments sains répondant à la sécurité alimentaire, en élargissant les processus de production durable, conformément aux paramètres établis par l'Organisation Mondiale de la Santé (OMS, 2006) et les Objectifs de Développement Durable des Nations Unies.

La thèse est structurée en 3 parties suite à cette introduction générale : la première correspond à une revue de littérature et présente une analyse conceptuelle à partir d'une macro approche et s´oriente vers des approches plus spécifiques. Cela signifie que le texte est issu d'une approche plus large liée aux politiques mondiales, telles que celles en relation avec les objectifs de développement durable et d´ l'agriculture durable, et issu d'une analyse plus ciblée sur l'évaluation d'impact et le rôle de l'innovation dans ces objectifs de durabilité.

La deuxième partie est consacrée à une partie méthodologique, présentant les étapes de production d'un proto-modèle et comment les quatre institutions de recherche ont été choisies pour participer au processus de benchmarking.

La troisième partie présente les principaux résultats de chaque étape et explique comment les étapes précédentes ont conduit au modèle conceptuel final du système de gestion de l'évaluation d'impact d'innovation.

Partie I – Revue bibliographique - Concepts et approches

Cette partie est divisée en quatre points :

1. Vers une agriculture durable ;

2. Le rôle de la recherche et de l'innovation dans la durabilité ;

3. L'importance d'évaluer l'innovation : en tenant compte des approches axées sur les impacts ;

4. La nécessité d'un modèle conceptuel pour réaliser une analyse d'impact.

Idées clés

En faisant une synthèse des concepts abordés dans l'analyse bibliographique, nous énumérons ici quelques points clés abordés dans la Partie I :

- Plusieurs types d'organisations ont investi du temps et des ressources pour mettre en place des systèmes d'évaluation d'impact pour leurs politiques, projets et activités.

- Les organismes de recherche doivent démontrer à leurs bailleurs de fonds publics ou privés l'avantage d'investir dans la recherche : c'est-à-dire quels seront les impacts sur l'économie, la société et l'environnement ? Les institutions supérieures de contrôle exigent la transparence des institutions publiques sur l'utilisation à bon escient des ressources publiques et sur l'impact de leurs activités. Les utilisateurs des solutions veulent des impacts positifs de la recherche et de l'innovation, ils attendent plus de productivité, moins de coûts de production et une plus grande rentabilité, par exemple. Le consommateur souhaite une bonne alimentation et avoir une bonne santé, résultant de systèmes de production chaque fois plus durables qui utilisent des solutions technologiques durables. Afin d'évaluer l'impact, il est nécessaire de suivre et de vérifier ces effets à différentes dimensions et échelles spatiales, mais aussi de les mesurer dans le temps, qu'ils soient directs ou indirects.

- Pour que la recherche produise des solutions techniques durables, elle doit intégrer les concepts de durabilité tout au long du processus d'innovation, depuis l'identification et la caractérisation des demandes à la phase de transfert de technologie et phase de post-transfert, c'est-à-dire pendant le suivi après transfert, absorption et adoption de la technologie par le client ou utilisateur.

- Le contexte structurel et le contexte comportemental représentent deux approches qui divisent les différents types d'évaluation, c'est-à-dire les aspects structurels (qui définissent les différents types d'impact), et les aspects comportementaux, qui considèrent plusieurs théories dans les domaines social, comportemental et de gestion, importantes pour assurer l'efficacité des processus d'innovation et d'évaluation.

Partie II - Approche méthodologique.

Pour identifier, analyser et évaluer les impacts de l'innovation, il est essentiel d'approfondir la science des systèmes d'innovation, ainsi que d'identifier les métriques, et plusieurs aspects liés aux contextes d'impact comportemental, économique, social, politique et environnemental. L'examen de la littérature sur ces questions et l'évaluation d'expériences concrètes sont fondamentaux (Jonkers et al, 2018). Cette thèse adopte une stratégie méthodologique générale appelée "méthode de stratégie de développement" (Contandriopoulos et al., 1994, p.41) qui vise à améliorer certaines technologies spécifiques, dans ce cas spécifique, un modèle d'évaluation de l'impact des innovations des recherches.

Le processus de modélisation a débuté par l'élaboration d'un proto-modèle fondé sur l'examen de la documentation, sur mes hypothèses, sur les choix théoriques fondés sur les principes de durabilité et sur l'adoption d'une vision intégrée. Cette stratégie méthodologique est présentée comme une stratégie de recherche qui vise à utiliser systématiquement les connaissances existantes, à élaborer une nouvelle intervention, à améliorer considérablement une intervention existante, ou à élaborer ou améliorer un instrument, un dispositif ou une méthode de mesure, y compris dans une optique qualitative. Cela signifie que ce proto-modèle est un cadre préconçu pour pouvoir appuyer et guider l'analyse des expériences, et, lors de l'étape suivante, aider à choisir ce qui devrait être revu dans chaque établissement d'étude de cas,

Cette thèse est donc basée sur une revue de littérature, sur une étude de cas de quatre expériences d'organismes de recherche, en relation avec systèmes d'évaluation d'impact de l'innovation (en particulier dans le secteur agricole), sur un processus d'analyse comparative (retenant ce qui a été identifié comme positif parmi ces expériences) pour finalement aboutir à un modèle conceptuel final du système d'évaluation d'impact d'innovation, comme décrit ci-dessous :

- **Revue de la littérature** - il s´agit de la base théorique essentielle pour enrichir les connaissances sur les discussions récentes (à partir de livres et d'articles) avec de nouvelles informations et de nouveaux concepts sur l'évaluation d'impact et les connaissances associées. Cela permet une discussion plus large et plus approfondie sur ce thème. Par conséquent, une analyse documentaire a été effectuée sur l'évaluation de l'impact (économique, social, politique et environnemental), les processus d'innovation, la durabilité, ainsi que sur les aspects comportementaux indispensables au succès des processus d'innovation et l'évaluation de l'impact, comme notamment les questions de gestion et de leadership ;

- **Le Proto-Modèle** - Basé sur une analyse documentaire, le proto-modèle sert de référence pour l'analyse des expériences des quatre organismes de recherche afin d'effectuer une analyse comparative, et finalement d'élaborer un nouveau modèle conceptuel du système d'évaluation d'impact de l'innovation.

- **Les études de cas** - - L'étude de l'expérience réelle des systèmes d'évaluation de l'impact de la recherche est essentielle pour comprendre comment les théories influent sur la réalité des organisations. De même, les systèmes d'évaluation de l'impact de l'innovation de quatre organismes de recherche agricole ont été étudiés, en consultant leurs lignes directrices, leurs manuels, leurs politiques et tous les types de documents organisationnels stratégiques et importants liés au processus d'innovation et à l'évaluation de l'impact de la recherche. Tout ceci fut un apport essentiel pour comprendre l'expérience méthodologique de chaque un de ces organismes de recherche. Parmi ces organismes choisis, on distingue l´INRA, le CIRAD de France, l´ Embrapa du Brésil et le CSIRO d'Australie, ´, acteurs moteurs de la production de technologies pour le marché des céréales, de la viande, des fruits et des produits laitiers, entre autres, ou encore les produits agro-industriels. Dans le cadre d'une phase de déploiement des études de cas, une activité de test d'outils de collecte de données sur le terrain a été incluse, pour laquelle certains acteurs de l'Embrapa ont été employés afin de tester certains outils : entretiens, réunions et visites de terrain, sans parler de l'analyse des données secondaires fournies par eux-mêmes et l'Embrapa.

- **Benchmarking** - une procédure de benchmarking a été instaurée pour identifier et progresser avec les expériences réussies, et ainsi améliorer le proto-modèle. Elle correspond à une étape nécessaire pour affiner le proto-modèle. Dans chaque établissement, un ensemble de procédures permettant d'évaluer la capacité d'innovation de leurs recherches a été répertorié. Les procédures et les approches jugées les plus appropriées en ce qui concerne le type de travail à effectuer ont été soulignées et analysées avec soin. On a ensuite cherché à insérer ceux qui pourraient fournir un système de gestion plus complet.

- **Le modèle conceptuel final du système d'évaluation de l'impact de l'innovation** - Après l'analyse documentaire, les études de cas et le processus d'analyse comparative, le proto-modèle a été examiné, et un modèle conceptuel définitif d'évaluation de l'impact de l'innovation des recherches a été présenté. Ce diagramme de flux global de la recherche est présenté sur la figure 1 ci-dessous.

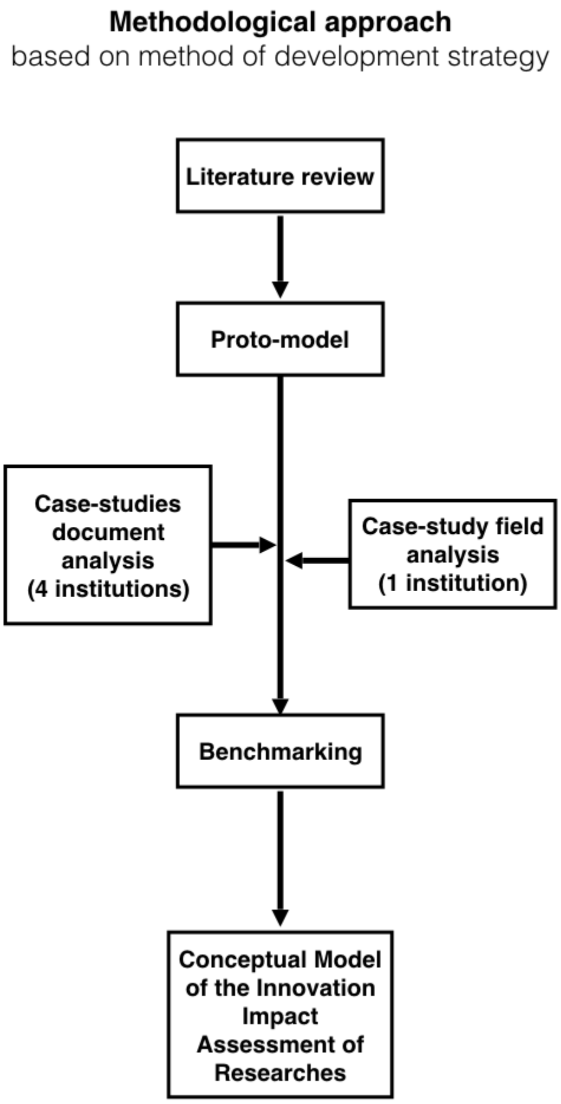


Figure 1. A general flow chart of the present research

Le développement du modèle proto-modèle

Cette thèse utilise une méthode qualitative pour analyser et discuter des descriptions théoriques et des méthodologies d'organisation de la recherche. Elle adopte des paramètres qualitatifs comme base pour construire le nouveau modèle du système de gestion de l'évaluation des impacts de l'innovation.

Huit références qualitatives ont été adoptées comme base du proto-modèle pour l'évaluation de l'impact de la recherche sur l'innovation :

a) Lien avec les politiques et stratégies institutionnelles ;

b) Existence d'une structure pour l'analyse d'impact ;

c) Lien avec le processus d'innovation ;

d) L'insertion du concept de constructivisme ;

e) L'insertion du concept d'holisme ;

f) L'insertion du concept de transdisciplinarité ;

g) Durabilité dans une perspective transversale ;

h) Analyse de processus.

La procédure de benchmarking

L'analyse comparative peut être définie sommairement comme le processus d'évaluation et d'application des meilleures expériences ou pratiques qui permettent d'améliorer la qualité d'autres processus ou pratiques organisationnelles (Ahmed et Rafiq, 1998).

S'approprier l'expérience de quatre organisations dans le domaine de l'évaluation de l'impact de la recherche représente le nec plus ultra sur ce thème, incarné par les institutions de recherche bénéficiant d´une grande renommée internationale, en identifiant les points positifs et les fragilités ou les lacunes à corriger ou à améliorer, en se concentrant sur la notion d'innovation. Cette analyse comparative a permis de vérifier que les aspects positifs identifiés pouvaient intégrer un nouveau modèle d'évaluation de l'impact de l'innovation, basé sur une approche transversale de la durabilité et renforcé par la pratique de l'évaluation comparative.

<u>Études de cas pour affiner le modèle proto-modèle</u>

En observant le scénario global du secteur de la production et du commerce agricoles, il est possible d'identifier certains acteurs importants dans les pays producteurs de denrées alimentaires tels que la France (au sixième rang mondial), le Brésil (au troisième rang) et l'Australie (au onzième rang). Sur le continent européen, la France est le pays le plus important en matière de production et d'exportation agricoles. Elle est y compris le pays qui absorbe le plus grand impact du secteur agricole sur son économie. Le Brésil est le premier pays d'Amérique latine en ce qui concerne la production et les exportations dans le secteur agricole. Bien qu'elle soit classée au 11ème rang mondial de la production et des exportations agricoles, l'Australie se trouve à la première place sur le continent océanien et constitue un exemple de résilience face aux défis du climat et des sols avec une agriculture hautement qualifiée. (FAO, 2015 ; Mediamax, 2016 ; AG, 2010).

Pour enrichir ce travail et créer une base concrète afin de développer cette thèse, nous avons décidé d'inclure des études de cas de quatre organismes de recherche provenant de ces trois pays. Ces études de cas sont importantes car elles permettent une analyse pratique et approfondie, y compris une confrontation entre les théories et le monde réel et, par conséquent, engendrent une base conceptuelle pour construire un nouveau modèle de système d'évaluation d'impact, applicable aux organisations de recherche agricole dans une perspective transversale de durabilité.

Les institutions choisies pour l'étude comparative sont les suivantes :

- En France - L'Institut national de la recherche agronomique - INRA et le Centre de coopération internationale en recherche agronomique pour le développement – Cirad (Cirad, 2015 ; Cirad, 2016) ;
- Au Brésil – la Société brésilienne de recherche agricole – Embrapa (Embrapa, 2018) ;
- En Australie – le *Commonwealth Scientific and Industrial Research Organisation* – CSIRO (CSIRO, 2018).

L'expérience de terrain

Le but de l'expérience sur le terrain est de tester certains outils de collecte de données et d'informations. Cette activité ne se veut pas une enquête de terrain avec beaucoup d'échantillonnage quantitatif, mais un moyen de tester certains outils d'enquête, par un travail qualitatif et perceptif de la réalité locale, avec un échantillon très ciblé dans une enquête détaillée de l'opinion de certains acteurs. Elle cible les responsables représentatifs du secteur agricole, qui sont les responsables d'associations représentant des milliers de producteurs.

Cette étape fut importante pour alimenter en données et en informations de terrain le nouveau modèle d'évaluation d'impact construit dans cette thèse. Cette activité fut donc importante en tant que mécanisme d'aide au choix des outils d'enquête les plus appropriés pour insertion au nouveau modèle à concevoir.

Le choix de l'institution pour le travail de terrain

Les outils de recherche auraient pu être testés dans n'importe quelle des quatre institutions étudiées, mais ils furent finalement testés par l'Embrapa, en raison des deux facteurs suivants :

a) la disponibilité des chercheurs de l'Embrapa pour assurer le travail de terrain ;

b) les facilités d'accès pour les acteurs de l'Embrapa, notamment auprès des producteurs ruraux travaillant sur des projets de terrain avec l'Embrapa, ainsi que les représentants des organisations du secteur, ou encore l'accès facilité des techniciens à la vulgarisation rurale.

Le processus d'apprentissage à partir du travail de terrain

Sur la base de la contextualisation ci-dessus, le but de l'expérience sur le terrain fut :

a) obtenir des données, des informations et des expériences méthodologiques pour alimenter la construction du modèle d'évaluation de l'impact de la recherche ;

b) analyser les meilleures options en termes d'outils de collecte de données et d'informations, en observant la réalité locale et en dialoguant avec les utilisateurs d’échantillon des technologies de l'Embrapa ;

c) identifier les points positifs, les lacunes et les obstacles tout au long des étapes du processus, depuis la formulation des politiques, de la recherche, en passant par le transfert de technologie, l'assistance technique aux actions pratiques des agriculteurs et ses réflexes liés à l'utilisation des outils de sondage.

Le modèle conceptuel final de l'évaluation de l'impact de l'innovation

Le modèle conceptuel final du système de gestion de l'évaluation de l'impact de l'innovation sera le résultat de toutes parties précédentes. Il constituera le produit final de cette thèse et sera détaillé dans la partie III. Ainsi, ce modèle sera le résultat de la revue de la littérature et de la pratique de benchmarking. Il sera notamment le produit de l´identification des aspects positifs détectés à partir de l'analyse comparative des quatre organismes de recherche, ainsi que de l'analyse spécifique d'un organisme de recherche sélectionné (l'Embrapa, dans ce cas), et après que des informations méthodologiques positives furent recueillies à partir de l'expérience de terrain.

Partie III - Le proto-modèle ; Étude de cas de quatre organismes de recherche : Observations et conclusion ; l´analyse comparative ; le modèle conceptuel final.

La partie III représente la dernière partie de cette thèse, qui se compose de quatre points : le Proto-Modèle ; Étude de cas de quatre organismes de recherche : Observations et conclusion ; le Benchmarking ; **le modèle conceptuel final**.

Cette partie vise à faire converger la base conceptuelle, synthétisée dans un proto-modèle, puis à entrer dans l'analyse de quatre expériences pratiques sur l'évaluation d'impact de l'innovation, à procéder à l'intégration des points positifs trouvés dans ces expériences, pour finalement arriver au modèle d'un système amélioré d'évaluation d'impact. La description de chaque point se trouve détaillée ci-dessous :

1. La description du proto-modèle est vérifiée à partir de l'analyse documentaire qui servira de référence pour l'analyse des quatre organismes de recherche étudiés.

2. Il est montré ici ce qui a été observé et conclu dans l'analyse des quatre organismes de recherche étudiés.

3. Il est présenté les aspects positifs et utiles de cette recherche et de la construction d'un modèle conceptuel qui en découle, aspects observés dans les expériences des quatre organisations étudiées.

4. Il est ici décrit le modèle conceptuel final, ses caractéristiques, les éléments d'évaluation à appliquer et d'autres aspects opérationnels, sur la base de l'analyse comparative, en complétant et en affinant le proto-modèle.

1. Le Proto-Modèle : une base conceptuelle pour le système d'évaluation d'impact d'une innovation

Le proto-modèle a été développé à partir de l'analyse bibliographique et visera désormais à servir de paramètre au le modèle d'évaluation de l'impact de l'innovation à construire. Après avoir analysé les expériences d'évaluation de l'impact de l'innovation de quatre organismes de recherche, l'étape suivante consista à améliorer le proto-modèle et à arriver à un modèle aussi idéal que possible, à faire appliquer par les établissements de recherche. Les citations suivantes résument les principaux aspects structuraux de l'ajustement du cadre de proto-modèle :

Le Proto-Modèle, comme le montre la figure 2 ci-dessous, a été élaboré à partir de l'analyse documentaire et représente le cadre conceptuel sur lequel s'appuie le système de gestion de l'évaluation d'impact du modèle d'innovation. Le Proto-Modèle démontre que le système d'évaluation d'impact est un système ouvert, avec un degré élevé d'interaction entre l'environnement organisationnel interne (de l'institution de recherche) et l'environnement, les facteurs sociaux, politiques et économiques, y compris les parties prenantes, les clients et les utilisateurs des solutions innovantes.

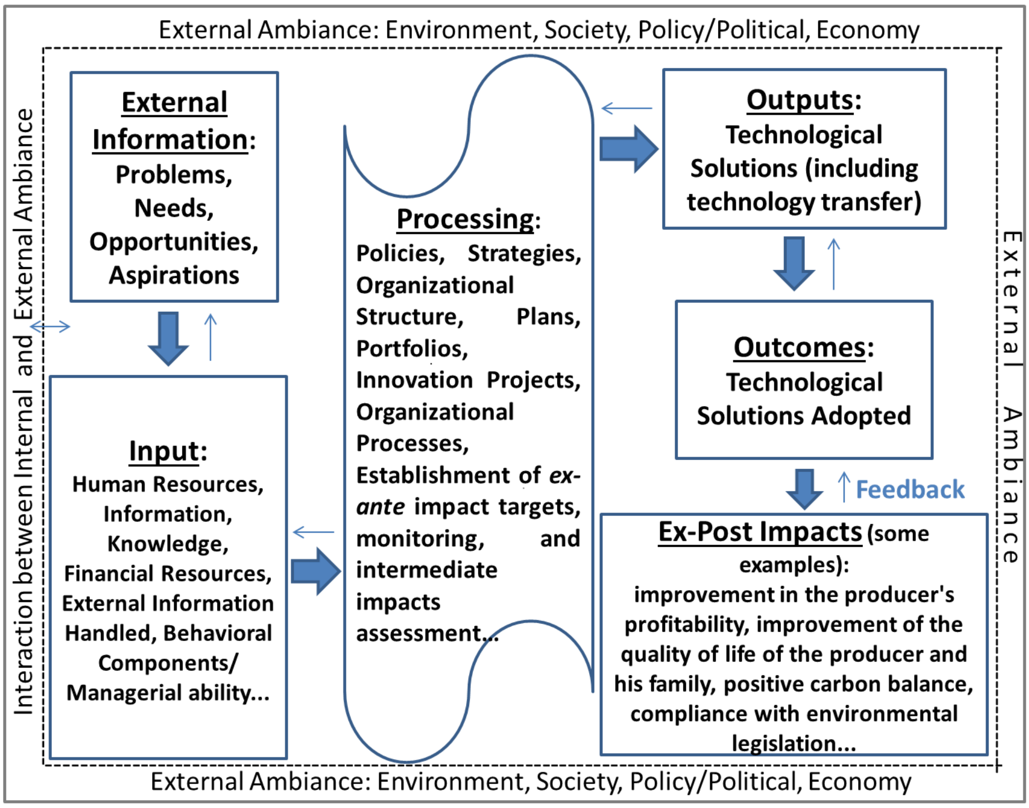


Figure 2. Proto-Model of Innovation's Impact Assessment Management System
Adapted from Jonkers et al. (2018), and Goldstein & Renault (2004).

Selon la figure 2, le proto-modèle adopte huit variables comme base structurelle qui imprégneront toutes les étapes du système ci-dessus (Jonkers et al., 2018 ; Goldstein et Renault, 2004 ; Kuby, 1999 ; Cato, 2009 ; Metherbe, 1986 ; Law et Kelton, 1991 ; Buckley, 1976 ; Markus et al., 2002 ; Rodrigues et al., 2010 ; Avila, Rodrigues et Vedovoto, 2008 ; Douthwaite, 2003 ; Joly, P. et al., 2016) :

- **Lien avec les politiques et les stratégies institutionnelles** - les informations et les signaux provenant de l'environnement extérieur devraient guider l'élaboration des politiques et des stratégies institutionnelles et, dans ce cadre, le système d'évaluation d'impact doit être inclus comme une priorité institutionnelle. De plus, il devrait y avoir un lien systématique entre les exigences et les besoins de l'environnement extérieur, le processus d'innovation et leur intégration avec le système d'évaluation de l'impact de l'innovation ;

- **L'existence d'une structure pour évaluer l'impact de l'innovation** - Il est essentiel que l'organisme de recherche ait une structure permanente pour gérer le processus d'évaluation de l'impact de l'innovation. C'est un bon moyen d'éviter les discontinuités dans les actions et de permettre un suivi continu des impacts générés par l'organisation, facilitant ainsi l'examen des politiques, stratégies et priorités de recherche ;
- **Lien avec le processus d'innovation de l'organisation** - en visant à suivre le processus d'innovation, étape par étape, le système d'analyse d'impact doit être couplé au système d'innovation, ce qui permettra de procéder à des ajustements de cap tout au long du processus d'innovation, grâce à une analyse d'impact ex-ante et, ultérieurement, de promouvoir des ajustements des politiques, stratégies et priorités d'innovation suite aux évaluations d'impact ex-post ;
- **Insertion de la vision constructiviste dans l'attitude des acteurs lors de l'opérationnalisation du processus d'évaluation d'impact** - l'intégration de concepts et de pratiques constructivistes doit être couplée avec la politique institutionnelle d'innovation, comme un moyen de garantir l'harmonie entre les demandes, politiques, priorités, processus de création d'innovation, et les étapes des impacts des innovations, et ces concepts doivent être présents dans l'évaluation d'impact des innovations comme une manière de donner la fiabilité des données et informations recueillies auprès des acteurs externes et internes ;
- **Concepts et pratiques de l'holisme** - L'insertion du concept d'holisme est essentielle dans le processus de proposition de solutions innovantes, ainsi que dans l'évaluation de leurs impacts. Comprendre que toutes les parties qui intègrent l'univers des acteurs externes et internes de l'organisation doivent participer à l'évaluation de l'impact de ces innovations, puisqu'elles sont indissociables, qu'elles aient une influence directe ou indirecte sur l'organisation

de recherche et sur ce qu'elle produit pour la société. Dans ce contexte, il est important de classer le degré d'importance et d'influence de chaque partie prenante, c'est-à-dire la façon dont elle peut influencer directement ou indirectement sur l´ élaboration de innovations et les impacts qui en résultent ;

- **Adoption des principes et pratiques de transdisciplinarité** - Ce concept désigne les formes d'action qui intègrent des personnes de différents domaines de connaissance et des institutions représentant l'environnement externe et interne à chaque étape de la construction de l'innovation et du processus d'évaluation d'impact, favorisant la synergie et l´élaboration de résultats favorables pour atteindre des impacts en phase avec les besoins et désirs des acteurs ;
- **Adoption des concepts de durabilité par une vision transversale** - Il est nécessaire non seulement d'intégrer les dimensions économique, sociale, politique et environnementale, mais aussi de les visualiser transversalement, interactivement et dans une perspective holistique, constructiviste et transdisciplinaire, ainsi que de faire une analyse intégrative entre toutes ces dimensions, en comprenant qu'il existe différentes valeurs entre elles (avec leur classification respective en importance - Cato, 2009) ;
- **Analyse des processus axée sur les chemins d'impact** - L'évaluation des impacts de l'innovation implique le suivi de chaque étape du processus d'innovation, depuis l'évaluation d'impact ex ante jusqu'à la production d'impacts post-innovation dans le temps (impacts ex post), y compris les retards d'impact, dans la société, dans l'économie et dans l'environnement.

2. Étude de cas de quatre organismes de recherche : Observations et conclusion

L'analyse comparative des méthodologies des quatre organisations (Cirad, INRA, Embrapa et CSIRO) relatives à l'évaluation de l'impact de la recherche a constitué une étape importante de cette thèse. Les études de cas ont adopté 8 variables : le lien avec les politiques et stratégies institutionnelles; l'existence d'une structure pour évaluer l'impact de l'innovation; le lien avec le processus d'innovation de l'organisation; l'insertion de la vision constructiviste dans l'attitude des acteurs lors de la mise en œuvre du processus d'évaluation d'impact; les concepts et pratiques d'holisme; l'adoption des principes et pratiques de transdisciplinarité; l'adoption des concepts de durabilité par une vision transversale; l'analyse des processus axée sur les chemins d'impacts.

Le tableau 1 qui suit est un résumé de l'analyse comparative entre les quatre institutions de recherche, en termes de systèmes d'évaluation de l'impact de l'innovation.

Tableau 1. Variables pour l'analyse comparative de quatre organisations

Variables	Cirad	Inra	Embrapa	CSIRO
Lien avec les politiques et stratégies institutionnelles	-	-	Partiel	Intégral
Existence d'une structure pour évaluer l'impact de l'innovation	Structure temporaire	Structure temporaire	Structure permanente	Structure permanente
Lien avec le processus d'innovation de l'organisation	Partiel	Partiel	Partiel	Partiel
Insertion de la vision constructiviste dans le comportement des acteurs lors de la mise en œuvre du processus d'évaluation d'impact	Intégrale	-	-	-
Insertion de la vision holistique dans le comportement des acteurs lors de la mise en œuvre du processus d'évaluation d'impact	Partiellement	Partielle	-	-
Insertion de la vision transdisciplinaire au comportement des acteurs lors de la mise en œuvre du processus d'évaluation d'impact	-	-	-	-
Adoption des concepts de durabilité par une vision transversale	-	-	Partielle	-
Analyse des processus en se focalisant sur les chemins d'impacts.	Partielle	Partielle	Partielle	Partielle

Le tableau 1 ci-dessus résume le degré d'interface entre chacune des huit variables et le système d'évaluation de l'impact de l'innovation de chaque établissement de recherche, en considérant que ce degré soit variable et parfois absent, (indiqué par un tiret -), ou présent partiellement ou intégralement. L'organisme de recherche peut disposer d'une structure temporaire ou permanente pour gérer le processus d'évaluation d'impact, voire ne pas disposer du tout d'une telle structure. On constate que chaque institution présente des caractéristiques différentes ou convergentes entre elles. L'approche transdisciplinaire est le seul paramètre qui n'ait pas trouvé de résonance dans chacune des institutions. Le Cirad et le CSIRO sont les seuls à avoir atteint le degré d'alignement complet. Le diplôme "partiellement" était le plus fréquent (douze fois) parmi tous les établissements.

2.1 L'expérience sur le terrain comme occasion de tester certains outils d'enquête

Les quatre organismes de recherche ont fait l'objet d'un examen de leurs systèmes d'évaluation de l'impact de l'innovation, mais pour des raisons de stratégie et de moyens limités fournis par les équipes de l'Embrapa, il a été décidé de choisir une seule institution (l'Embrapa) et un échantillon de leurs parties prenantes pour tester les instruments des enquêtes de terrain. L'Embrapa est une des organisations de recherche agricole les plus active de l'agro-industrie dans le monde, et qui représente le mieux l'adoption des technologies agricoles tropicales, avec des impacts significatifs sur la production et sur le marché des céréales, des viandes et des biocarburants.

Il est important de souligner que toutes ces analyses ont été limitées aux outils d'enquête adoptés par les modèles de l'Embrapa (Social Balance Report et Ambitec-Agro). L'expérience sur le terrain a apporté des contributions précieuses en ce qui concerne les outils d'enquête, pour la construction du nouveau modèle du système d'analyse d'impact. Ces outils ont été testés, par exemple, pour recueillir l'opinion des parties prenantes. Leurs résultats ont été importants pour confronter certaines inférences sur plusieurs informations socio-économiques et environnementales, collectées sur le terrain avec les informations qui ont été insérées dans le Rapport sur l'équilibre social 2017 de l'Embrapa. Il a également été possible de vérifier dans les rapports de terrain (en confrontant la réalité et les données secondaires) la qualité du résultat de la méthodologie Ambitec-Agro, après son application.

Il est important de bien décrire une observation importante faite sur le terrain et d´en tirer des leçons. Lors des entretiens, les formalités ont démontré qu'elles créent une autoprotection des personnes interrogées, créant un climat de dissimulation, alors qu'elles peuvent omettre ou mentir sur certaines informations. Pour le nouveau modèle d'évaluation d'impact de l'innovation, il est recommandé d'adopter un large éventail d'outils d'entretien basés sur les instruments semi-structurés et non structurés, et l'intervieweur doit également avoir les compétences nécessaires pour utiliser ce type d'approche.

3. Analyse comparative : les aspects utiles du modèle identifiés chez les quatre organisations.

3.1 Quelques outils importants acquis lors de l'expérience de terrain et applicables à un nouveau modèle d'analyse d'impact

Ce paragraphe est directement à relier au paragraphe 2.1.

Selon le concept de base du benchmarking, il ne suffit pas d'intégrer ou de s'inspirer des points positifs d'autres organisations, il est nécessaire d'identifier les lacunes ou les possibilités de niveler l'expérience des autres. Ensuite, en observant les aspects positifs des méthodologies étudiées crédibles de benchmarking, ainsi que les données et informations vérifiées sur le terrain, il fut possible d'identifier d'importantes lacunes et faiblesses méthodologiques qui, au final, alimenteront le nouveau modèle à concevoir, visant à obtenir un système amélioré.

En concluant sur les analyses d'outils utilisées et observées lors de l'expérience terrain, plusieurs recommandations ont pu être faites pour un nouveau modèle d'analyse d'impact de l'innovation :

- Il s'agit d'études techniques locales indispensables et centrées sur les composantes environnementales (axées sur les ressources en eau et leur qualité, la qualité des sols, la conservation de la biodiversité et le paysage productif, en plus des aspects sociaux, économiques et culturels) ;
- L'utilisation des géotechnologies associées à l'observation locale ;
- L'adoption d'entretiens semi-structurés et également non structurés ;
- Le processus d'évaluation doit être dirigé par un organisme externe et indépendant, sans l'intervention de l'organisme de recherche qui fait l'objet du processus d'évaluation (même si cet organisme a élaboré la méthodologie).

Toutes les données détaillées, les résultats, les analyses et les outils adoptés au cours de l'expérience sur le terrain sont disponibles en annexe (annexes 1, 2 et 3).

3.2 Résumé du benchmarking avec les instituts de recherche

Sur la base de la bibliographie et conformément aux concepts d'analyse comparative, cet élément vise à résumer d'autres points importants tirés de l'expérience des quatre organismes de recherche, en complément des aspects qui pourraient être améliorés.

Résumant le *benchmarking* au système de gestion de l'évaluation d'impact du nouveau modèle conceptuel de l'innovation (points positifs intégrés par les quatre institutions analysées et mise à niveau de leurs systèmes d'évaluation d'impact) :

Tableau 2. Principales contributions à intégrer dans le prototype en vue d'un nouveau modèle d'évaluation d'impact

Variables	Autres principes indispensables, aspects structurels et comportementaux à prendre en considération
Lien avec les politiques et stratégies institutionnelles	+ S'aligner sur les objectifs de développement durable de l'ONU, en particulier les objectifs 2 et 12. + Être en phase avec les demandes et les aspirations de la société (y compris les composantes économiques et politiques), avec les besoins de conservation écologique et la résilience environnementale. +Être transparent dans la construction et la mise en œuvre des politiques, des stratégies, des projets d'innovation et des processus organisationnels, jusqu'aux extrants, aux résultats et aux impacts, en démontrant aux acteurs, aux financiers et à la société le retour sur investissement.
L'existence d'une structure pour évaluer l'impact de l'innovation.	+ Adopter une structure permanente d'évaluation des impacts, avec des équipes continues et formées, des ressources financières et matérielles.
Le lien avec le processus d'innovation de l'organisation.	+ Adopter une architecture d'innovation ouverte (et après une plate-forme d'innovation ouverte détaillée) comme exigence de base à coupler avec le processus d'analyse d'impact. + Adopter une interaction/un dialogue large et continu avec les parties prenantes.
L'insertion de la vision constructiviste dans comportement des acteurs lors de la mise en œuvre du processus d'évaluation d'impact. L'insertion de la vision holistique dans l'attitude des acteurs lors de la mise en œuvre du processus d'évaluation d'impact. L'insertion de la vision transdisciplinaire dans l'attitude des acteurs lors de la mise en œuvre du	+ S'assurer qu'il y a une large participation des acteurs internes et externes pendant le processus d'innovation et le processus d'évaluation d'impact, ainsi que la capacité de toutes les parties prenantes par la formation continue, les ateliers, les réunions et le dialogue informel et ouvert, en visant à instaurer un climat de confiance et de respect entre eux et entre les coordinateurs internes et les autres acteurs. + S'assurer que les scientifiques et les non-scientifiques sont intégrés et à l'écoute pendant le processus d'innovation et le processus d'évaluation de l'impact. + Pour s'assurer que le processus d'analyse de l'analyse d'impact soit impartial, cela signifie qu'il doit être conduit par une organisation indépendante et externe. + S'assurer que toutes les disciplines (qui sont en interface avec le thème en discussion et en construction) sont représentées dans les équipes d'innovation et d'évaluation d'impact, et qu'il y a des événements pour développer la

processus d'évaluation d'impact.	synergie, l'empathie et un dialogue ouvert entre tous les acteurs.
L'adoption des concepts de durabilité par une vision transversale.	+ Prendre en compte la dimension durable des impacts en intégrant les composantes économiques, politiques, sociales et environnementales dans une perspective transversale. + Éviter la segmentation entre toutes les dimensions considérées, et les voir toutes selon une perspective managériale unique, en s'efforçant d'insérer chaque dimension les unes dans les autres pendant le processus d'analyse.
Analyse des processus en se focalisant sur les chemins d'impacts.	+ Comprendre que le système sera axé sur l'analyse des voies d'impact (à l'intérieur et à l'extérieur de l'organisation de recherche, en tenant compte, au cours du processus de planification, des impacts ex ante prévus, ainsi qu'après l'étape des résultats, ce qui signifie évaluer les impacts ex-post). + Insérer un système de gestion global et intégré d'évaluation de l'impact de la recherche, jouant le rôle de "parapluie" les impacts *ex-ante* et *ex-post.* + Prendre en compte les aspects de mesure des impacts comme l'échelle temporelle, l'échelle spatiale, la durée des impacts et enfin l'intensité des impacts.

4. <u>Le modèle conceptuel final du système de gestion de l'évaluation de l'impact de l'innovation (IIAMS), selon une perspective transversale de durabilité</u>

4.1 <u>Aperçu général du modèle</u>

Le nouveau modèle développé dans cette thèse intègre les approches bibliographiques et les expériences remarquables acquises par les quatre organismes de recherche étudiés. Pour combler les lacunes non prises en compte par ces organismes, le nouveau modèle indique une vision systémique en insérant un système de gouvernance et de gestion de l'évaluation des impacts, en adoptant les principes de benchmarking. Ce système tend à se synchroniser avec le processus d'innovation en recherche et il recommande que l'organisme externe et indépendant conduise le processus d'évaluation.

Le modèle conceptuel du système de gestion de l'évaluation d'impact de l'innovation - IIAMS conçu ici, bien qu'il puisse être adapté à d'autres types d'organismes de recherche, s'adressera particulièrement aux organismes de recherche agricole et partira d'une approche macro systémique vers des micro approches, c'est-à-dire, qu´il partira d'un modèle général et par la suite se partagera en analyse spécifique de ses composantes.

L'IIAMS pourrait s'appuyer sur les processus d'innovation existants dans n'importe lequel des organismes de recherche étudiés dans cette thèse, mais il fut proposé de trouver un modèle qui se rapproche le plus possible de l'ensemble des points positifs identifiés dans l'examen théorique et les méthodologies institutionnelles étudiées. De cette façon, il devient essentiel de faire du benchmarking et, par conséquent, de proposer un modèle innovant en accord avec le cadre philosophique tel qu'illustré dans le tableau 2.

Qu'est-ce que le modèle IIAMS ?

L'IIAMS est un système qui vise à gérer le processus d'évaluation d'impact d'un organisme de recherche, principalement orienté vers le secteur agricole et dans une optique de durabilité. On entend ici le secteur agricole comme faisant partie des chaînes d'approvisionnement avant et après la ferme, , impliquant les chaînes liées aux secteurs de l'agriculture, de l'élevage, de la foresterie et de l'aquaculture ainsi que la multifonctionnalité des exploitations agricoles, les activités liées au développement rural sur des bases durables, ainsi que les industries et services liés à ces secteurs. L'IIAMS est basé sur le fil conducteur défini dans le tableau 2.

L'IIAMS est un outil de gouvernance et de gestion d 'appui à la prise de décisions. Grâce à des retours d'informations sur les impacts des innovations et l'écoute des parties prenantes, eil aide à ajuster les politiques, les plans stratégiques, les projets de recherche et d'innovation, ainsi que les processus organisationnels.

IIAMS est un système qui visualise et coordonne les évaluations ex-ante (prévision des scénarios d'impact) et ex-post (à la fois ex-ante et ex-post, axées sur la réalité sociale, politique, économique et environnementale) d'une manière intégrée et dans une approche de gestion unique et interactive. Le système est basé dans le sens de l'impact, qui est couplée au processus d'innovation. Il va de même au-delà de l'étape des résultats puisqu'il cherche à suivre les voies d'impact dans l'environnement économique, social, politique et écologique, tout en respectant les différentes échelles d'espace et de temps et en considérant les retards. En effet, suite à l'adoption d'une solution technologique, il est normal qu´un décalage vis-à-vis des impacts apparaisse.

L'IIAMS est un système composé de plusieurs parties ou processus par phénomènes d´interrelation, d´interaction et d´inter influence. Cette théorie générale des systèmes est le travail de base qui fondera le concept global de système d'évaluation d'impact ainsi que le modèle d'innovation ouverte proposé (Buckley, 1976 ; Geyer et Zouwen, 1992 ; Japiassu et Marcondes, 1989 ; Bertalanffy, 1968). Ainsi, dans le cadre du système de gestion de l'évaluation d'impact, il existe une évaluation des impacts intermédiaires, allant de la phase d'identification des demandes de la société (secteur productif et autres parties prenantes) à la phase initiale des résultats. Ensuite, une évaluation de l'étape des extrants et des résultats est réalisée avant l'évaluation des impacts *ex post*. L'évaluation des impacts intermédiaires est en fait une évaluation des processus tout au long du parcours de l'innovation. Cependant, on la dénommera dorénavant l'étude d'impact intermédiaire pour créer, fixer et étendre la culture d'impact au sein de l'organisme de recherche et avec les différents acteurs internes et externes.

À chaque phase d'innovation, se trouveront des "passerelles" d'impact, à l'intérieur desquelles seront utilisés des outils de gestion pour évaluer les impacts intermédiaires, ainsi que pour évaluer les produits et les résultats. La phase d'évaluation *ex post* disposera également d'outils de gestion appropriés. Tous ces outils seront décrits en détail dans le paragraphe concernant le cadre et le fonctionnement du système.

4.2 La définition de l'architecture général de l'innovation :

L'idéal serait de construire une plate-forme d'innovation détaillée, qui pourra être utilisée pour une recherche future. Pour autant, il n'est pas question ici de développer une plate-forme d'innovation complète et détaillée, mais simplement une architecture générale de plate-forme d'innovation pour créer un cadre ou une piste initiale dans lequel le modèle du système d'évaluation d'impact de la recherche pourra être encadré et ensuite pour effectuer son analyse.

L'architecture général de cette innovation est une référence théorique pour l'IIAMS, basée sur la Figure 2 (le Proto-Modèle) et la théorie générale des systèmes, et adopte comme principes générales les points suivants :

- Toute innovation adoptera des principes éthiques, le respect de l'environnement, de la société et des lois en vigueur en la matière.
- Le processus d'innovation aura pour objectif premier d'aider l'ONU à atteindre ses objectifs de développement durable, sur ce qui relève de son champ d'action.
- Le processus d'innovation sera ouvert, sous réserve d'engagements contractuels ou de partenariats qui établissent la confidentialité ou des degrés variables de

restriction, impliquant une interaction ouverte uniquement entre les personnes et les chercheurs autorisés par le contrat respectif ou la durée du partenariat, selon le cas.

- Le processus d'innovation, y compris toutes ses étapes, fera l'objet d'un niveau élevé d'engagement de la part des parties prenantes.
- Le processus d'innovation sera imprégné dans toutes ses étapes par les principes et concepts de durabilité, y compris les étapes d'évaluation d'impact, pour garantir la gestion de ce qui est créé pendant le cycle de vie des produits insérés dans les diverses chaînes de production et dans les environnements écologiques, sociaux, politiques et économiques.
- Le processus d'innovation intégrera les concepts de constructivisme, d'holisme et de transdisciplinarité comme moyen de garantir l'efficacité de l'engagement de toutes les parties prenantes, en tenant compte des scientifiques et des non-scientifiques, tout au long des étapes de l'innovation, en fonction de chaque cas ou des besoins d'échange d'informations.
- Le processus d'innovation adoptera des principes et des pratiques de leadership collaboratif et agile, pour développer des pratiques de gestion avancées, axées simultanément sur le processus, les résultats et les impacts, en considérant que l'être humain est le centre de motivation et le garant de la réalisation des objectifs visés.
- Le processus d'innovation stimulera en permanence la créativité des acteurs internes et externes de l'organisme de recherche, parallèlement à l'orientation innovante.

4.3 L'IIAMS comme outil de gouvernance et de gestion, et ses composantes

4.3.1. L'IIAMS comme outil de gouvernance et de gestion

Le système de gestion de l'évaluation d'impact de l'innovation a un rôle de gouvernance lié aux engagements envers la société, à la responsabilité environnementale, à la promotion de la durabilité économique, à la responsabilisation, à l'établissement de mécanismes de gestion pour faciliter la réalisation des objectifs d'impact et à la durabilité institutionnelle.

4.3.2. Composantes de l'IIAMS

L'IIAMS se compose des éléments suivants : principes, valeurs de l'impact, définition des dimensions de l'impact, paramètres des indicateurs de l'impact, nature de l'impact ou classification de l'impact, caractéristiques de l'impact, intensité de l'impact, échelles d'impact, niveau des impacts, fréquence de l'impact, amplitude de l'impact.

4.3.2.1. Principes opérationnels de l'IIAMS

- L'IIAMS doit être lié aux politiques et stratégies institutionnelles et sera aligné sur les objectifs de développement durable des Nations Unies, en particulier les objectifs 2 et 12 ;
- L'IIAMS doit être en lien et en synchronisme avec le processus d'innovation de l'organisation, qui envisagera une architecture d'innovation ouverte ;
- L'IIAMS adoptera l'analyse de processus centrée sur la filière d'impact en examinant les impacts ex ante et ex post dans une perspective systémique de gestion ;
- Les IIAMS doivent adopter les concepts de durabilité par une vision transversale, en intégrant les dimensions économiques, politiques, sociales et environnementales ;
- L'IIAMS mettra en place un cadre permanent d'évaluation des impacts de l'innovation ;
- L'IIAMS insérera des concepts et des pratiques de constructivisme, en adoptant des mécanismes pour motiver un processus participatif avec des acteurs externes et internes, avec même une interaction avec les parties prenantes ;
- L'IIAMS adoptera des concepts et des pratiques d'holisme avant, pendant et après toutes les étapes de l'innovation et tout au long du processus d'évaluation d'impact, avec des équipes transdisciplinaires, comprenant des décideurs, des scientifiques et des non-scientifiques ;

- L'IIAMS adoptera des mécanismes d'impartialité pour conduire le processus d'évaluation d'impact, ce qui signifie qu'une entité externe et indépendante sera chargée de conduire le processus, bien que l'organisme de recherche ait élaboré la méthodologie à utiliser à cet effet.

4.3.2.2. Valeurs de l'impact

Les impacts ont des valeurs tangibles et des valeurs immatérielles. Il existe des valeurs mesurables et non mesurables. Certains types d'impacts peuvent ne pas être mesurés par la vision mathématique parce que dépassant les valeurs économiques, ou même peuvent ne pas être fondés sur des mesures quantitatives environnementales. Les valeurs économiques sont mesurables alors que les valeurs culturelles ou sociales ne le peuvent pas car étant intangibles. Elles peuvent être plongées dans une grande complexité, comme dans le cas de la biodiversité en général (dans un contexte d'écosystème diffus, complexe et large). Ou bien encore, elles ne peuvent pas être mesurées parce qu'elles représentent une expression des valeurs culturelles, spirituelles ou sociales (valeur) au sens large de la citoyenneté, du bien-être et de l'épanouissement personnel.

4.3.2.3. Définition des dimensions de l'impact : environnementale, sociale, politique et économique

Les impacts environnementaux sont tous les impacts qui affectent l'environnement interne et externe dès qu´une technologie particulière fut adoptée, c'est-à-dire ses effets affectent plusieurs échelles spatiales :de l´environnement sont directement ou indirectement affectées par l'utilisation de cette technologie. Des impacts environnementaux peuvent également se produire tout au long de la chaîne d'approvisionnement, tels que ceux liés au cycle de vie du produit (avant, pendant et après le traitement productif, lors de la période post-récolte et dans filière agricole, ceux liés aux bilans énergétique et bilan carbone, ou même ceux liés à la production de déchets solides et d'effluents localement ou par la chaîne de production.

Les impacts sociaux peuvent être considérés comme tous les effets provenant d'une technologie qui affecte l'environnement social local, régional, national et mondial, dans le cadre d'arrangements productifs ou de chaînes de production, mais aussi la qualité de vie, la nutrition et la santé, le bien-être, la culture et engendre d´autres impacts qui touchent directement ou indirectement les consommateurs. L´amélioration de la qualité de vie de la famille de l'agriculteur, l´amélioration du niveau de nutrition et de la santé générale de sa famille et des consommateurs peuvent être indirectement affectés par une initiative de recherche donnée.

Les impacts politiques peuvent être compris dans un contexte de structure politique ou de processus politique. Dans un contexte structurel la politique peut être comprise comme une politique publique, ou une politique économique, politique fiscale, politique sociale, politique de santé, politique environnementale, etc. et tous ses dérivés, c'est-à-dire les plans ou les programmes à développer. Comprendre la politique dans un contexte de processus politique, l'impact politique en tant que processus signifie l'évaluation du discours politique et de la façon de gouverner, c'est-à-dire, que l´on considère les aspects comportementaux du dirigeant ou du gestionnaire pendant le processus de construction, de mise en œuvre et de gestion des politiques publiques ou même des politiques entrepreneuriales e ou d'une organisation non gouvernementale (ONG).

L'impact économique peut être entendu comme la technologie de production influant t la production de l'agriculteur et donc générer des impacts positifs ou négatifs sur son économie (par exemple : amélioration de sa rentabilité, amélioration de la capacité d'achat des intrants pour sa production). Un autre type d'impacts économiques sont les réflexes de la chaîne de production dans laquelle le ou les produits générés par l'agriculteur ont une incidence, comme ses conséquences sur le PIB de la municipalité, de la région ou du pays, et ses effets sur les consommateurs et les économies des autres pays qui ont importé et acquis le produit.

4.3.2.4. Indicateurs de l'impact - Paramètres

En mesurant l'impact, il est nécessaire d'établir des paramètres d'indicateurs liés à la situation précédente et après l'adoption d'une certaine technologie. Cette analyse comparative permettra d'établir la différence entre les deux temps: avant et après l'adoption d'une solution technologique par l'agriculteur ou le secteur productif. Dans ce contexte, il faut être conscient que dans de nombreux cas, un impact est dû à la somme ou à l'interaction de plusieurs facteurs, provenant d'origines et de moments différents. Cet environnement peut rendre complexe l'identification exacte d'une solution donnée sur l'impact environnemental, social et économique alors qu'elle est insérée dans un contexte diffus comme une mosaïque d'inter-influences, d'interdépendances, d'interactions et d'effets de chaîne.

Malgré cela, il est important d'identifier les différentes origines et époques liées aux différentes causes d'impact sur un certain environnement, sur la chaîne d'approvisionnement, sur le groupe social, sur le PNB (Produit Intérieur Brut) du pays, et sur tout type d'aspects liés à l'impact.

4.3.2.5. Natures de l'impact ou classification de l'impact

L'impact se manifeste de plusieurs façons. L´IIAMS classifie la nature de l'impact selon la Qualité et les Types.

La qualité de l'impact peut être définie comme positive ou négative. Parfois, un produit ou une technologie peut être positif par sa dimension économique et négatif par sa dimension environnementale. Il est nécessaire de disposer d'une échelle pour identifier la qualité de l'impact. Et elle ne peut se limiter exclusivement au négatif ou au positif, mais, dans une échelle spécifique, elle peut être plus ou moins positive ou négative. Toutefois, tout processus d'évaluation devrait adopter la transparence comme principe majeur.

Les types d'analyse d'impact ou le calendrier de l'analyse d'impact sont décrits selon deux moments : *l'ex-ante* et *l'ex-post*.

4.3.2.6. Caractéristiques d'impact

Il peut être intentionnel ou involontaire, intermédiaire ou final. Avant d'arriver chez le producteur, une solution technologique fut testée et validée. Cependant, il est possible qu'en arrivant sur le terrain, et à grande échelle, elle génère des impacts imprévus ou non, c'est-à-dire des impacts non intentionnels. Les impacts involontaires peuvent également être considérés comme des externalités, c'est-à-dire lorsqu'une solution est adoptée et qu'elle génère des effets indésirables.

Les impacts intermédiaires sont ceux qui se produisent au cours des étapes de l'innovation jusqu'à ce qu'ils atteignent les résultats, qui seront la dernière étape de l'évaluation intermédiaire. A partir des résultats, l'évaluation finale de l'impact commence, c'est-à-dire que commence l'étape *ex-post*, jusqu'aux étapes de l'évaluation d'impact en cours, qui peuvent atteindre différentes chaînes de production dans le temps.

4.3.2.7. Intensité de l'impact

L'intensité de l'impact représente le niveau de force ou l'intensité de l'impact, qu'il soit faible, moyen ou élevé.

Avec l'utilisation d'une échelle allant de -3 à +3, il sera possible de faire fusionner deux caractéristiques de l'impact : le niveau d'intensité et la qualité de l'impact. L'échelle -3 sera la plus négative, -2 la négative moyenne, -1 la moins négative, le niveau 0 (sans impact négatif ou positif remarquable), +1 avec un impact positif faible, +2 avec un impact positif moyen et +3 avec un impact positif élevé.

4.3.2.8. Échelles d'impact

L'échelle d'impact concerne l'ampleur de l'impact, qui possède deux dimensions : le temps et l'espace. Dans une optique temporelle, on distingue des impacts à court, moyen, long, très long, extrême long termes et des impacts pérennes. Dans ce cadre, il est nécessaire de prendre en compte les impacts décalés, c'est-à-dire leur durée dans le temps : de nombreux types d'impact peuvent retarder les effets sur l'économie, la politique, la société ou encore l'environnement.

Un impact à court terme est un impact qui se produit immédiatement dans la limite d´un an au plus tard. L'impact à moyen terme est se produit au-delà d'un an, et ce jusqu'à cinq ans. L'impact à long terme lui se produit au-delà de cinq ans, jusqu'à vingt ans. L'impact à extrême long terme arrive à plus de 20 ans, et ce jusqu'à 100 ans. Un impact pérenne ou persistant signifie que, sur une centaine d'années, il peut toujours persister. Au cours de l'analyse d'impact (à la fois *ex ante* et *ex post*), il est crucial de considérer le type d'innovation technologique généré.

L'impact en perspective d'échelle spatiale désigne l'espace géographique où se produit l'effet d'un produit ou d'un service (réflexes d'adoption d'une technologie. Il peut s'agir d'espace local (à l'intérieur de l´exploitation agricole), d'espace municipal, d'espace étatique ou régional, d'espace rural et d'espace international (voire global). Habituellement, les impacts locaux sont des impacts à l'intérieur même de l'exploitation qui auront des impacts directs sur l'environnement, l'économie et les paramètres sociaux du producteur (tels que la santé, l´éducation et la qualité de vie).

4.3.2.9. Niveau des impacts

Ils peuvent être directs, indirects et dépliés (générant des séquences de déroulement ou des effets de chaîne dans différentes chaînes d'approvisionnement). Les impacts directs sont considérés comme des impacts de premier niveau; les impacts indirects de deuxième niveau et les impacts dépliés de troisième niveau.

Impacts directs et indirects

L'impact direct peut être défini comme un effet direct sur quelqu'un ou sur quelque chose. Habituellement, les impacts directs se produisent sur les utilisateurs directs d'une solution donnée. C'est l'effet direct sur une exploitation agricole et son propriétaire qui provoque des réflexes économiques et sociaux, y compris sur l'environnement. Les impacts indirects sont ceux qui surviennent après les impacts directs. Normalement, les impacts indirects se produisent sur les utilisateurs indirects. L'impact déplié ou effet de chaîne est celui qui affecte une chaîne de production différente de celle qui était directement liée au produit d'origine, pouvant causer un effet de chaîne avec une extension sur différentes chaînes d'approvisionnement industrielles, de services et de consommation.

Les impacts qui se sont déroulés

Ces types d'impacts sont ceux qui ont des effets successifs dans les chaînes de production, différents de ceux initialement liés au produit généré par l'utilisation d'une certaine technologie. C'est-à-dire qu'après qu'une technologie donnée ait eu un impact donné sur les effets indirects dans une chaîne de production donnée, ces effets peuvent s'étendre à d'autres chaînes de production. On peut les qualifier d'impacts tertiaires, pouvant survenir à court, moyen ou long terme (les impacts secondaires sont indirects et les impacts primaires sont directs). Il est important de souligner que dans ces impacts tertiaires doivent être mesurés selon les dimensions économiques, politiques, sociales et environnementales des différentes chaînes d'approvisionnement ou entreprises qui peuvent être générés en fonction du temps écoulé.

4.3.2.10. Fréquence de l'impact

La fréquence de l'impact est une mesure importante pour ceux qui discerneront les risques et les niveaux de dommages et pour ceux qui ont été potentiellement ou réellement affectés par l'impact. Cette mesure devrait servir de paramètre pour la prise de décision concernant les mesures préventives (dans le cas d'une évaluation ex ante) ou les mesures correctives ou de minimisation pour l'évaluation ex post. La fréquence peut être :

- Constante
- Récurrente (intermittente)
- à Pièces uniques
- Variable et Inconstante
- Imprévisible

4.3.2.11. Amplitude de l'impact (sur les personnes, les secteurs ou l'environnement)

Souvent, un impact ne mérite pas beaucoup d'attention s´il est peu marquant ou du moins il nécessite moins d'attention que les autres qui produisent un impact plus important. Ainsi, un impact de grande amplitude (ou même moyenne) méritera une attention particulière, et des mesures préventives (dans le cas d'une évaluation ex ante), ainsi que des mesures correctives ou réductrices (dans le cas d'une évaluation ex post) devront être prises. La classification par amplitude sert de point de référence, à l'établissement, des priorités décisionnelles en matière d'intervention ou d'action préventive. L´amplitude de l'impact dépend de la vision ou du sentiment de ceux qui sont potentiellement ou réellement affectés, qu'il s'agisse d'un secteur public, d'un secteur productif ou d'une partie de la société, ou des membres représentatifs de l'environnement (par exemple, scientifiques, militants écologistes).

Du point de vue des parties prenantes et des secteurs économique, politique et social[23], on peut considérer une amplitude :

---

[23] Economique : secteur productif en général ou segments spécifiques des producteurs, industrie, commerce, chaînes d'approvisionnement... ; Politique : décideurs politiques, institutions gouvernementales, parlement,

- A fort impact pour toutes les parties prenantes et tous les secteurs
- Élevée seulement pour certains intervenants ou secteurs (détail)
- Moyenne pour tous
- Moyenne pour certains intervenants ou secteurs (détail)
- Faible pour tous
- Faible pour certains intervenants ou secteurs (détail)

En ce qui concerne la dimension environnementale, l´amplitude de l'impact sera mesurée en fonction des indicateurs suivants :

- Élevé (préciser le composant)
- Moyen (précisez le composant)
- Faible (précisez le composant)

4.4 Concepts de durabilité et approches comportementales tout au long du processus d'évaluation d'impact

Une prise de conscience profonde et cohérente de la réalisation des objectifs des Nations Unies en matière de développement durable devrait inciter tous les acteurs à développer une culture du développement durable au sein de l'organisation et tout au long de l'innovation et sur l'évaluation d'impact. L'attachement à cet objectif, associé à l'appropriation de comportements appropriés par les responsables, les chefs de projet, les équipes et toutes les parties prenantes, devient un point crucial pour le succès de l'IIAMS. L´objectif des résultats escomptés de l'IIAMS est étroitement liée à l'agrégation, au partage, au respect et aux postures de coopération interpersonnelle des dirigeants et des membres des projets, comme conditions essentielles pour permettre un engagement efficace des acteurs internes et externes.

Toutes les étapes du processus d'innovation doivent être marquées par une approche holistique, transdisciplinaire et constructiviste, ce qui présuppose une interaction totale avec

pouvoir judiciaire... ; Social : populations locales, régionales ou nationales, groupes sociaux spécifiques, familles des producteurs, populations traditionnelles...

les acteurs internes et externes ainsi qu´une certaine motivation pour développer une culture d'impact et une attitude d'innovation ouverte entre tous. Le comportement holistique, constructiviste et transdisciplinaire, pendant la construction de l'innovation, aidera à créer une culture de l'impact parmi les acteurs, et ce comportement devrait rester tout au long du processus d'évaluation d'impact intermédiaire et final.

4.5 Le système de gestion de l'évaluation d'impact du modèle d'innovation – IIAMS

La figure 3, présentée ci-dessous, illustre l'essentiel de la thèse en présentant le modèle résumé du système de gestion de l'impact de l'innovation, en montrant les impacts généraux et les interrelations entre ses éléments, et en indiquant les flux de base du système.

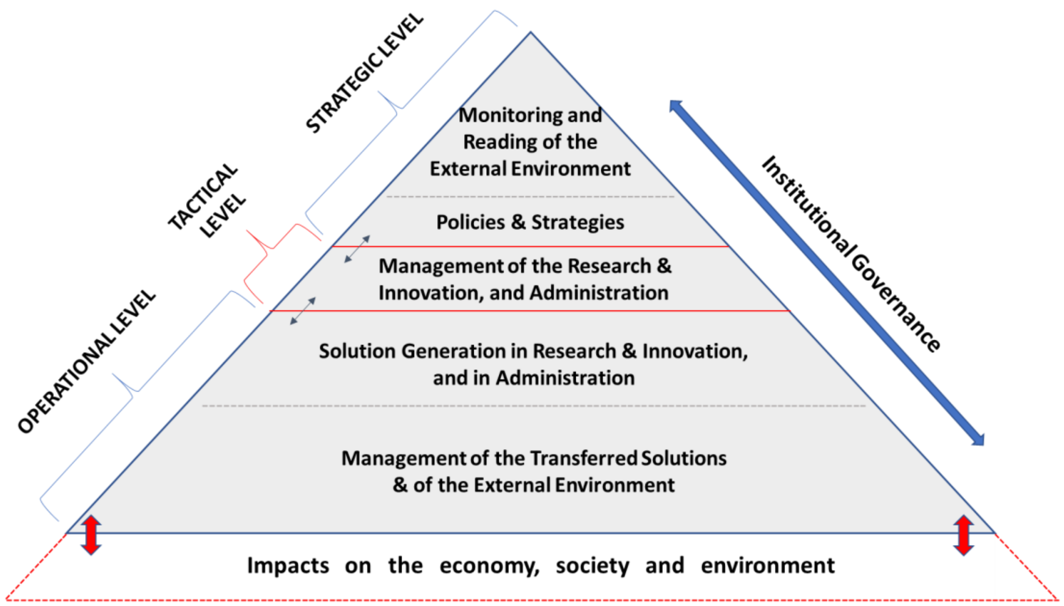


Figure 3. Modèle résumé du système de gestion de l'impact de l'innovation

Le niveau stratégique de l'organisme de recherche et d'innovation fait la lecture de l'environnement externe et établit les politiques et les lignes directrices pour la recherche et l'innovation ainsi que pour l'administration. Ces deux processus exigent un dialogue permanent avec les parties prenantes. A ce niveau, les principaux objectifs d'impact *ex ante* ou les impacts attendus par l'organisme de recherche sont déjà établis (prévision des impacts stratégiques). Sur le plan tactique de l'organisation, il s'agit de la gestion exécutive de la recherche et de l'innovation et de l'administration, basée sur les politiques et stratégies définies par le niveau stratégique (top management). Sur la base des objectifs d'impact stratégique, ce niveau définit les portefeuilles d'innovation des projets et les grands processus de gestion. A ce niveau, les portefeuilles de projets auront un impact sur les objectifs (ou sur les grands programmes d'innovation).

Au niveau opérationnel, les projets de recherche et les processus de gestion sont organisés et développés, de même que les solutions attendues (extrants) et leurs résultats, lorsque les innovations technologiques sont réalisées. La gestion de l'innovation devrait également se faire à ce niveau au post-transfert de la solution (comme cela se passe après la vente dans le cas de la commercialisation de produits ou des technologies). Elle implique de satisfaire les utilisateurs ou les clients, ainsi que d'évaluer tout type d'impact sur l'environnement extérieur (en considérant toutes les parties prenantes, l'économie, la société et l'environnement écologique).

En résumant l'analyse descriptive de l'IIAMS, on peut distinguer cinq grandes étapes :

- La lecture de l'environnement externe ;
- L'élaboration de politiques et de lignes directrices ;
- L´élaboration de solutions en matière d'innovation ;
- L'adoption de solutions ; et
- L'étape d'impact.

Les voies d'impact se produisent au sein de l'organisme de recherche (même s'il y a interaction avec l'environnement externe), produisant des impacts intermédiaires, et à l'extérieur de l'organisme, produisant des impacts directs, indirects et non étendus, là où les voies sont plus complexes et donc, en exigeant des approches plus globales et complexes en matière de suivi et d'évaluation. Ce suivi et cette évaluation devraient inclure une analyse environnementale du contexte économique, politique et social et impliquer le plus grand nombre possible de parties prenantes, qui devront être classées par ordre d'importance par rapport à l'influence directe ou indirecte sur l'institution, ses produits et ses résultats. Ces mesures se refléteront dans la qualité et le degré de viabilité institutionnelle.

4.6 Stratégie d'évaluation de l'impact de l'innovation à l'échelle spatiale et indicateurs de durabilité

L'évaluation d'impact devrait reposer sur une stratégie d'intervention reposant sur deux dimensions d'échelle : spatiale et temporelle.

Nous n'avons pas envisagé l'échelle de temps dans cette base de planification en raison de la complexité du facteur temps dans l'analyse d'impact, étant donné qu'il y a la question du retard, de façon que plusieurs des impacts se manifestent, générant ainsi une désynchronise entre les facteurs temps et espace.

Lorsqu'il s'agit d'un très large univers de variables (impliquant plusieurs espèces végétales, l´interaction avec le bétail, sans compter les prototypes, les logiciels et autres technologies d'origine non biologique), l'imprévisibilité temporelle devient complexe. Les facteurs biologiques et environnementaux permettent une très large ouverture du spectre, et deviennent encore plus importants, compte tenu des réactions biologiques dues à des facteurs climatiques, par exemple. Dans des conditions naturelles, la tendance est que lorsqu'un produit s'éloigne de son centre de production (dimension spatiale), il lui faudra plus de temps pour atteindre sa fin et donc si on observe ses impacts sur la dimension spatiale, ce qui entraîne des impacts plus tardifs que les impacts locaux.

Mais cette hypothèse n'est pas vraie. De nos jours, la dimension temporelle suppose une dynamique différente lorsqu'il s'agit d'accélérer le transport terrestre ou aérien, ce qui accélère l'entrée des produits sur les différents marchés nationaux et mondiaux, et peut générer des impacts plus rapides sur le marché global que sur le marché national, ou même sur place, notamment sur le plan économique. Et dans le contexte environnemental, l'impact serait presque simultané pour le cas des émissions de carbone.

En se concentrant sur l'analyse d'impact, l'IIAMS adopte comme stratégie d'intervention à l'échelle spatiale comme base de planification. Ainsi, on part de l´échelle locale, en passant par l´échelle régionale jusqu´à l´échelle du pays, voir jusqu´au niveau international. Le mouvement inter-échelle se produit lorsque divers espaces géographiques sont traversés par des éléments qui intègrent des processus naturels (flux et courants d'eau, phénomènes atmosphériques, tels que la température de l'air, la pression atmosphérique, les flux de vent, l'humidité de l'air, l'évaporation, les nuages et les précipitations, sans compter la transpiration des plantes, les processus géologiques, la pollinisation, ou la migration animale) et par les chaînes logistiques ou marchés.

<u>Idées clés</u>

La partie 3 s'articulait autour de quatre points :

- La définition du proto-modèle en tant que référence initiale d'un modèle d'évaluation de l'impact de l'innovation, qui devrait servir de base à l'analyse des expériences acquises par quatre organismes de recherche ;
- S'inspirer du proto-modèle, pour analyser l'expérience de ces quatre organismes de recherche, concernant leur modèle d'évaluation de l'impact de l'innovation ;
- Le benchmarking, c'est-à-dire l'identification des points importants dans les quatre expériences étudiées, favorisant ainsi l'amélioration de ces points ;
- La construction d'un modèle amélioré d'évaluation de l'impact de l'innovation, avec une attention particulière sur les organismes de recherche agricole.

Le modèle final amélioré est le résultat de la convergence des connaissances théoriques (fondées sur une analyse documentaire) et des expériences de quatre organismes de recherche. Appuyé par la théorie générale des systèmes, ce modèle englobe les huit variables apparues depuis la conception du proto-modèle, ainsi qu'un ensemble de détails qui représentent le développement de l'IIAMS avec ses définitions de base, ses composantes et son mode de fonctionnement.

L'IIAMS met l'accent sur les aspects de durabilité, essentiels pour que les organismes de recherche et les processus de production puissent atteindre les objectifs de développement durable imposés par l´l'ONU. Le nouveau modèle met également l'accent sur les aspects comportementaux (tels que la vision holistique, constructiviste et transdisciplinaire, ainsi que l'insertion de questions de leadership agile), en tant que différentiel pour conduire efficacement les processus d'évaluation de l'impact de l'innovation (et qu´il est recommandé d´insérer à chaque étape du processus 'innovation).

Conclusion générale et suggestions pour les recherches futures

Le principal résultat attendu du fonctionnement efficace du système de gestion de l'évaluation d'impact de l'innovation est d´appuyer la gouvernance et la gestion organisationnelles, en influençant positivement sur l'amélioration continue des politiques d'innovation et des stratégies des projets de recherche. Il sera exploité grâce aux rétroactions du système qui devraient aider l'organisation à atteindre une durabilité croissante dans sa production de solutions technologiques, de manière à ce que les systèmes agricoles et leurs filières puissent être de plus en plus durables, atteignant ainsi les objectifs de développement durable de l'ONU (en particulier les objectifs 2 et 12).

Le monde doit réduire les inégalités sociales, éliminer la faim et accroître durablement la production alimentaire. Les organismes de recherche agricole sont donc des acteurs clés de ce scénario et doivent répondre directement à ces besoins, d´ores et déjà validés par les Nations Unies.

La plupart des organismes de recherche agricole du monde entier cherchent déjà à internaliser les objectifs de développement durable de l'ONU. Ainsi, l'évaluation de l'impact dans le domaine économique, politique, social et environnemental de ces recherches et donc de ces innovations devient fondamentale dans un objectif de recherche croissante de la durabilité des pays et de la planète.

On espère que les organismes de recherche agricole pourront de plus en plus trouver des solutions technologiques durables afin de promouvoir une agriculture chaque fois plus durable.

Partant de ce point de vue, proposer l'amélioration des systèmes d'analyse d'impact était un produit important de cette thèse, comme moyen de contribuer aux efforts en faveur du développement durable, ainsi qu'au soutien des processus décisionnels des institutions de recherche, en particulier celles du secteur agricole. L'IIAMS entend soutenir la redéfinition des priorités de l'innovation en recherche, en réponse aux attentes de leurs parties prenantes.

On s'attend à un équilibre entre les désirs et les attentes de la société (y compris dans les dimensions sociales, politiques et économiques) ainsi que les besoins dont l'environnement a besoin pour sa résilience. Un bilan responsable devra être le protagoniste des exigences futures des institutions supérieures de contrôle des finances publiques, par la demande d´une évaluation de l'impact de l'innovation dans le cadre de cet équilibre requis par les organismes de recherche.

Les organisations mettent en œuvre des politiques, des plans, des programmes, des projets et des activités, et créent des produits et des services. Mais, par la suite, ces mêmes organisations génèrent des impacts et des conflits d'intérêts. Tous ces conflits et impacts pourraient être bien gérés si les organisations créaient des systèmes cohérents d'évaluation d'impact.

La complexité du thème et l'imbrication des dimensions environnementale, sociale, politique et économique demandent une vision essentiellement holistique, constructiviste et transdisciplinaire, exigeant une création plus large de méthodologies intégratives d'évaluation d'impact dans une perspective de durabilité, et utilisant une approche transversale pour l'analyse, ainsi qu'une approche souple du leadership dans ses processus de gestion et de gouvernance. Peu de méthodologies et d'expériences ont montré un équilibre entre toutes ces dimensions et, en général, ces méthodes ou pratiques sont adoptées partiellement, mettant l'accent sur un aspect plutôt qu´un autre.

En outre, les approches d'analyse d'impact tendent à se focaliser exclusivement sur l'analyse des impacts *ex ante* ou *ex post*. À l'heure actuelle, les organismes de recherche ne mettent l'accent que sur une ou deux composantes parmi les dimensions environnementales, sociales, politiques ou économiques. Cependant, l'IIAMS repose sur une approche qui tient compte de l'équilibre entre toutes ces dimensions. Cette nouvelle approche vise donc à réviser le concept d'analyse d'impact dans une perspective globale, y compris les phases *ex ante* et *ex post* dans le cadre d'un système d'évaluation unique, qui devrait être géré de manière intégrée. Les rapports délivrés par l'IIAMS seront utiles pour les processus décisionnels stratégiques, tactiques et opérationnels, pour l´obtention de subventions pour ajuster les politiques, plans, programmes, processus, projets, produits et services, en vue d'une production plus durable.

Nous avons adopté une stratégie méthodologique appelée « stratégie de méthode de développement » (Contandriopoulos et al., 1994, p.41) qui vise à améliorer certaines technologies spécifiques, en l'occurrence un modèle de système d'évaluation d'impact de l'innovation.

De cette façon, la thèse basée sur une revue de littérature a, à partir de celle-ci, proposé un proto-modèle comme référence de base pour la construction d'un modèle amélioré d'évaluation d'impact de l'innovation, avec une attention particulière aux organismes de recherche du secteur agricole. Après l´étape du proto-modèle, nous avons cherché à analyser l'expérience de quatre organismes de recherche (Cirad, Inra, Embrapa et CSIRO), dans une perspective de benchmarking. Ces organismes sont considérés comme des institutions de référence dans le monde et sur leurs continents, comme résumé ci-dessous.

Bien que plusieurs aspects tels que les questions structurelles, comportementales, de chaîne d'approvisionnement et autres aient été analysés, sept ? facteurs ont été adoptés comme référence principale dans l'étude :

- Le lien entre le système d'analyse d'impact et les politiques et stratégies institutionnelles ;
- L'existence d'un cadre pour l'analyse d'impact dans l'organisme de recherche (en tant qu'unité organisationnelle, ressources et personnel) ;
- Le lien entre le système d'analyse d'impact et le processus d'innovation ;
- Le processus d'innovation et d'analyse d'impact selon les concepts du constructivisme, de l'holisme et de la transdisciplinarité ;
- Une approche durable selon une perspective transversale ;
- Et l'analyse des impacts examinée à partir du processus, dans une perspective de cheminement, y compris une analyse d'impact dans une perspective temporelle *ex-ante* et *ex-post.*

En général, chaque institution a montré un aspect ou un autre d'une manière plus structurée et plus performante que l'autre. Par example : Le CSIRO a clairement établi un lien entre ses politiques et stratégies institutionnelles et son système d'évaluation d'impact. Le Cirad et l'Inra disposent d'un cadre non fixe pour leur processus d'évaluation d'impact, qui est piloté par des projets spécifiques, tandis que l'Embrapa et le CSIRO disposent d'un cadre fixe pour participer au processus d'évaluation d'impact. Bien que les quatre organismes citent l'innovation comme un acteur clé du processus de production scientifique et technologique, ils n'ont pas de lien systémique et couplé entre le processus d'innovation et l'évaluation des impacts.

A l'exception du Cirad, qui a une vision large du constructivisme dans le cadre de la construction du processus d'innovation et de l'évaluation de l'impact de l'innovation, les autres institutions ne font aucune inférence sur cette approche, et aucune d'entre elles n'intègre clairement une vision holistique et transdisciplinaire dans leur processus d'évaluation d'impact. Le Cirad et l'Inra font référence aux objectifs de développement durable de l'ONU, différents des autres institutions. D'autre part, l'Embrapa a une approche beaucoup plus affirmée vers une vision durable, ce qui a été observé dans son modèle d'évaluation d'impact. Le CSIRO et l'Embrapa citent la voie de l'impact dans leurs méthodologies, cependant, sur cette perspective, le Cirad et l'Inra sont plus emphatiques dans leurs approches. Le Cirad a travaillé sur des évaluations ex ante et ex post, sans toutefois les aborder de manière systémique et intégrée. Les autres institutions n'abordent en revanche que les évaluations ex post.

Le tableau 3, ci-dessous, résume la thèse en démontrant ses principaux objectifs, les résultats obtenus et les impacts attendus :

Tableau 3. Résumé de l'analyse comparative entre cet objectif de la thèse et ses résultats

Objectifs	Résultats	Impacts des résultats (avantages)
Synthèse des approches d'évaluation d'impact et des méthodologies d'analyse d'impact des quatre organismes de recherche - Cirad, Inra, Embrapa et CSIRO, vers un étalonnage.	- Les quatre institutions de recherche étudiées présentent des aspects positifs en ce qui concerne l´ articulation entre leurs politiques et stratégies institutionnelles et le processus d'évaluation de l'impact de la recherche. Concernant le cadre de l'évaluation de l'impact, seuls l'Embrapa et le CSIRO disposent d'une structure permanente de suivi et d'évaluation des impacts de la recherche. Le Cirad et l'Inra travaillent sur des projets spécifiques ; Le processus d'innovation est considéré par les quatre institutions comme la base du processus d'évaluation d'impact. Cependant, l'approche du Cirad, bien qu'elle ne représente pas un couplage exact, est celle qui se rapproche le plus de l'idée d'un chevauchement du modèle d'évaluation d'impact avec le processus d'innovation, fondé sur une vision systémique ; aucune des institutions n'aborde systématiquement les aspects	- Les théories et approches anciennes et récentes ont joué un rôle important dans l'élaboration du nouveau modèle au cours de l'analyse documentaire, et des points positifs ont été relevés dans les quatre organismes de recherche étudiés. - Il a été mis en évidence les points forts identifiés en tant que contribution à l'étalonnage des performances. Ils ont été insérés dans la nouvelle conception du modèle d'analyse d'impact de l'innovation, ainsi que dans la vérification des lacunes ou des points à améliorer qui ont également été intégrés dans le nouveau modèle.

	comportementaux dans leur intégralité (holisme, constructivisme, transdisciplinarité et approches en gestion), comme le recommande IIAMS. Malgré cela, le Cirad adopte une approche cohérente du constructivisme ; seuls le Cirad et l'Inra citent dans leurs approches les objectifs de développement durable de l'ONU, ainsi que l'importance de construire des modèles d'évaluation d'impact de la recherche. Cependant, le modèle de l'Embrapa est celui qui se rapproche le plus d'une approche transversale de la durabilité, mais qui peut être amélioré ; les quatre institutions traitent la voie de l'impact comme des points clés dans le processus d'évaluation, mais le Cirad et l'Inra sont ceux qui appliquent davantage cette question en termes d'étapes méthodologiques, notamment le modèle Cirad. - Le modèle IIAMS tire les points forts suivants de l'expérience des quatre institutions : l'accent mis sur la voie de l'impact ; le couplage entre le processus d'innovation et le processus d'évaluation d'impact ; le lien entre les politiques et stratégies institutionnelles et le processus d'évaluation d'impact ; l'insertion des concepts de constructivisme comme aspect essentiel du comportement pour le succès du modèle ; une structure organisationnelle permanente pour coordonner le processus de recherche sur les impacts ; une vision intégrée de la durabilité.	
Modèle conceptuel du système de gestion de l'innovation de l'analyse d'impact		- Un modèle amélioré ayant inséré d'importantes approches comportementales comme pratiques essentielles pour le succès de sa mise en œuvre, a été le résultat de pratiques positives de l'organisation de recherche étudiée, par approche de benchmarking. - L'IIAMS sera un important outil de gouvernance et de gestion pour la prise de décision dans la (re)conception et la (re)définition des priorités des politiques, des plans, des projets de recherche et l'amélioration continue de l'innovation pour les organismes de recherche. - On s'attend à ce que le nouveau modèle puisse aider les organismes de recherche (en particulier ceux du secteur agricole) à atteindre les objectifs de développement durable de l'ONU, notamment l'objectif 2.

Le modèle développé ici complète et aide les modèles actuels, y compris l'approche de l'Embrapa dans les aspects liés au système de gestion pour le suivi et l'évaluation des impacts grâce à une vision unique et intégrée de cette gestion. Une autre contribution de cette thèse fait référence à l'approche comportementale, avec une vision intégrée des concepts d'holisme, de constructivisme, de transdisciplinarité et de gestion agile, qui, en général, sont superficiels ou fragiles, voire inexistants dans la plupart des systèmes actuels d'évaluation d'impact de la recherche.

Cette thèse apporte également une vision transversale via une perspective de durabilité qui permet une classification des indices d'impact en tenant compte du fait que la dimension environnementale représente un contexte plus grand que les autres, puisque on retrouve en son sein les aspects sociaux, politiques et économiques. Il convient de mentionner que la dimension politique a été ajoutée au processus d'évaluation selon deux approches : l'une liée à la structuration des politiques publiques, son élaboration, sa mise en œuvre et l'évaluation de ses impacts, l'autre liée aux impacts issus des processus politiques (gouvernance). Par exemple, la manière de conduire une stratégie d'innovation (une politique mal gérée peut condamner à l'échec une politique publique ou une stratégie d'innovation).

Pour appliquer l'IIAMS, il est indispensable d'élaborer un guide opérationnel capable de traduire dans le monde réel chaque étape, avec des détails méthodologiques, y compris la spécification du cadre de gestion exécutive du processus dans son ensemble.

En termes d'avancées dans l'amélioration du modèle, il est suggéré un travail de terrain qui implique d'autres biomes et d'autres dynamiques agricoles, d'une part visant la validation de ce modèle et d'autre part, l'affinement de certaines données de recherche, telles que le nombre d'acteurs à impliquer tout au long de la chaîne logistique et les coûts d'application du modèle.

La prochaine étape sera ma réintégration à l'Embrapa et, dans ce processus, j'espère pouvoir y implanter l'IIAMS afin de promouvoir des améliorations du processus d'évaluation de l'impact de la recherche et de l'innovation actuellement en cours. Pour que ce modèle devienne fonctionnel, il sera nécessaire de disposer d'un guide opérationnel, ce qui sera un prochain travail à y développer.

Références bibliographiques

Ahmed, P.K. and Rafiq, M. (1998). Integrated benchmarking: a holistic examination of select techniques for benchmarking analysis. Benchmarking for Quality Management and Technology, Vol. 5 No. 3, pp. 225-42.

Asif, Chris and Gash, Alison. (2007). Published by Oxford University Press on behalf of the Journal of Public Administration Research and Theory, doi:10.1093/jopart/mum032.

Avila, A.F.D.; Rodrigues, G. S.; Vedovoto, G. L. (2008). Avaliação dos impactos de tecnologias geradas pela Embrapa: metodologia de referência. Embrapa Informacao Tecnologica. ISBN 978-85-7383-420-8. Available at : https://www.embrapa.br/busca-de-publicacoes/-/publicacao/15196/avaliacao-dos-impactos-de-tecnologias-geradas-pela-embrapa-metodologia-de-referencia, accessed 02/08/2018.

Barros de Mendonca, Savio & Laques, Anne-Elisabeth. (2017). Sustainability Impact Assessment – An Overview with a Holistic and Transdisciplinary Perspective towards Agricultural Research. Edited by Environmental Management and Sustainable Development Journal – Macrothink Institute. ISSN 2164-7682 2017, Vol. 6, No. 2. Available at: http://www.macrothink.org/journal/index.php/emsd/article/view/11333/9169.

Becker, Henk A. (2001). Social impact assessment. European Journal of Operational Research 128 311-321, www.elsevier.com/located/dsw.

Buckley, W. (1976) A sociologia e a moderna teoria dos sistemas. Trad. O. Cajado), 2ed, São Paulo, Cultrix, pp 9-68.

Cato, Molly Scott. (2009). *Green Economics*. London: Earthscan, pp. 36–37. ISBN 978-1-84407-571-3.

Centre de cooperation internationale en recherche agronomique pour le developpement – Cirad. (2015). The Impress ex post method: a co construction process with our partners. Available at: https://impress-impact-recherche.cirad.fr/ex-post/the-impress-ex-post-method.

Centre de coopération internationale en recherche agronomique pour le developpement – Cirad. (2016). Qui sommes-nous ? Notre strategie. Available at: https://www.cirad.fr/qui-sommes-nous/notre-strategie, accessed 02/18/2018.

Commonwealth Scientific and Industrial Research Organisation – CSIRO. (2018). Corporate Plan 2018. Available at: www.csiro.au.

Contandriopoulos, A. P.; Champagne, F.; Potvin, L.; Denis, J.-L. & Boyle, P. (1994). Saber preparar uma pesquisa. São Paulo: Hucitec-Abrasco.

Douthwaite, Boru; Kubyb, Thomas; Fliertc, Elske van de and Schulzd, Steffen. (2003). Impact pathway evaluation: an approach for achieving and attributing impact in complex systems. Agricultural Systems 78 (2003) 243–265, doi:10.1016/S0308-521X(03)00128-8. Available: http://boru.pbworks.com/f/ag_syst_IPE.pdf, accessed 01/23/2018.

Empresa Brasileira de Pesquisa Agropecuária – Embrapa. (2018).Organization's main site, available at: www.embrapa.br, accessed 03/18/2018.

Feenstra, Gail. (2018). UC Sustainable Agriculture Research and Education Program, University of California, Davis. Available at: http://asi.ucdavis.edu/programs/sarep/about/what-is-sustainable-agriculture.

Food and Agricultural - FAO. (2017). FAO representative in Brazil presents world demand for food. Available at: http://www.fao.org/brasil/noticias/detail-events/en/c/901168/.

Grey, D.; Garrick, D.; Blackmore, D.; Kelman, J.; Muller, M.; Sadoff, C. (2015). Water security in on blue planet: twenty-first century policy challenges for science. Philosophical Transactions of the Royal Society, June 22, p.1-10.

Joly, P., Pierre Benoit Joly, Laurence Colinet, Ariane Gaunand, Stephane Lemarié, Mireille Matt. (2016). Agricultural research impact assessment: issues, methods and challenges. [Research Report] auto-saisine. 2016, 51p. <hal-01431457>. Available at: https://hal.archives-ouvertes.fr/hal-01431457/document, accessed 03/03/2018.

Jonkers, K., Tijssen RJW, Karvounaraki, A., Goenaga, X, A. (2018). Regional Innovation Impact Assessment Framework for universities; EUR 28927 EN; Publications Office of the European Union, Luxembourg, 2018; ISBN 978-92-79-77048-7; doi:10.2760/623825; JRC109020.

Kuby, T., 1999. Innovation as a Social Process: What Does this Mean for Impact Assessment in Agricultural Research. Paper presented at a CIAT workshop, Costa Rica, September 1999.

Markus, Lynne M.; Majchrzak, Ann; Gssser, Les. (2002). A Design Theory for Systems that Support Emergent Knowledge Processes. MisQuarterly – Special Issue. Vol. 26, No. 3 (Sep., 2002), pp. 179-212. Published by Management Information Systems Research Center, University of Minnesota.

Metherbe, J.C. Conceito de Sistemas. (1986). Análise de sistemas, Rio de Janeiro, Ed. Campus, pp.31-43.

Ministerio da Agricultura, Pecuaria e Abastecimento – Mapa. (2018). Assuntos: Sustentabilidade, Plano ABC. Institutional main site, available at: www.agricultura.gov.br.

Rodrigues, Geraldo Stachetti ; Buschinelli, Cláudio and Avila, Antonio Flavio. (2010). An Environmental Impact Assessment System for Agricultural Research and Development II: Institutional Learning Experience at Embrapa. Journal of Technology Management & Innovation
J. Technol. Manag. Innov., Volume 5, Issue 4 p.38-56. Available at: http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-27242010000400004.

United Nations - UN. (2015). Transforming our world: the 2030 Agenda for Sustainable Development. General Assembly. Resolution adopted by the General Assembly on 25 September 2015 (seventieth session). Available at: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.