# Indicator framework and future visions guiding transition pathways for a sustainable Brazilian agri-food system

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Submitted in accordance with the requirements for the degree of
Doctor of Philosophy

The University of Leeds

School of Earth and Environment

Sustainability Research Institute

January 2019

The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

Acknowledgments

I dedicate this research to my great **family**, especially to my mother **Vera** and to my father **João** (in memoriam)**.**

This research was funded by a PhD scholarship from Coordination for the Improvement of Higher Education Personnel (CAPES), Brazil and a grant for fieldwork from the Sustainability Research Institute, University of Leeds.

I would like to give my entire appreciation to my three supervisors: Gerd Sparovek for being my tutor for CAPES's funding and giving me all support needed in this journey. John Barret for accepting to become and carry on as my main supervisor and giving me loads of insights and all support needed; Julia Steinberger for constantly challenging me to go further and explore new limits, thoughts and ways to deal with them and for her inspiring support.

I would like to express my gratitude to my mother and family for their incredible incentive and love. To my marvellous friends Imma and Paki! One more box ticked in our everlasting partnership! To my amazing colleagues for the great time and help at SRI and Leeds, David, Paola, Marco, Lina, Kate, Laura, Joy, Dan.

My dearest "family-friends" from Spain and Brazil, I am on my way…

Elke, for bringing me another meaning for the word home…

Abstract

The hegemonic food security discourse proposes the increase of agricultural productivity and intensification of land use to increase food production and address the two main challenges of agri-food systems: access to adequate food and reduced environmental impacts. This perspective feeds neoliberal free market ideology and technological revolution, thereby masking crucial issues of power, injustice and inequalities. Using Brazil as an example, this doctoral research develops a broader understanding of the agri-food system, its sustainability, key drivers and challenges, and designs possible solutions for agri-food challenges in a participatory way. A hierarchical indicator framework is developed to assess the sustainability of the Brazilian agri-food system from a broader perspective, taking into account multi-functionality, multidimensionality, policy relevance and applicability of results and outcomes. Subsequently, a backcasting participatory framework is designed to develop two transition pathways towards a sustainable Brazilian agri-food system. The pathways follow contrasting ideas and insights from local stakeholders: a top down reformist approach aligned with food security discourse; and a bottom up transformational approach aligned with food sovereignty discourse (the right to food and to produce food). The results of the indicator framework suggest that Brazil's national policies perform relatively better in terms of access to food and trade balance, reflecting food security targets. However, taking into account broader sustainability considerations such as biodiversity conservation, traditional communities, use of agrochemicals, equity and justice, the overall performance is weak. Results from the transition pathways show that actions emphasising food sovereignty would achieve better sustainability outcomes. However, both pathways are unlikely to be implemented in the short term. Pathways towards a sustainable Brazilian agri-food system would be more effective if they combined initiatives from both approaches. The main implementation challenge lies with civil society mobilization. Social movements need to build a common agenda and form alliances to achieve better sustainability outcomes.

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Abbreviations

ABC Plan – Low Carbon Agriculture Policies

ABRASCO – Brazilian Association of Collective Health

ANATER – National Agency of Technical Assistance and Rural Extension

AoA – Agreement on Agriculture from World Trade Organization

APP – Permanent Preservation Area (Environmental Legislation)

ATER – Technical Assistance and Rural Extension

BBB – Cattle, Bible and Bullet, parliamentarians from Brazilian Lower and Upper house aligned with agribusiness, religion and arms industry lobby

CAR – Rural Land and Environmental Management Registry

CEPEA – Centre for Advanced Studies on Applied Economics

CF – Forestry Code (Environmental Legislation)

CMN – National Monetary Council

CONAMA – National Environment Council

CONDRAF – National Council on Sustainable Rural Development

CSA – Community Supported Agriculture

EMATER – State Enterprise of Technical Assistance and Rural Extension

EMBRAPA – Brazilian Agricultural Research Corporation

FAO – Food and Agriculture Organization of the United Nations

IAASTD – International Assessment of the Agricultural Knowledge, Science, Technology and Development of UNEP

IBAMA – Brazilian Institute of the Environment and Renewable Natural Resources

IBGE – Brazilian Institute of Geography and Statistics

ICSU – International Council for Science

INCRA – National Institute for Colonization and Land Reform

INPE – National Institute for Space Research

IPC – International Planning for Food Sovereignty

IPEA – Applied Economic Research

ISSC – International Social Science Council

IUCN – International Union for Conservation of Nature

MAPA – Ministry of Agriculture, Livestock and Food Supply, Brazil

MDA – Ministry of Agricultural Development, Brazil

MDG – Millennium Development Goals

MMA – Environmental Ministry, Brazil

MST – Landless Rural Workers' Movement

MTE – Ministry of Work and Employment

PAA – Programme of Food Acquisition

PES – Payment for Ecosystem Services

PLANAPO – National Plan for Agroecology and Organic Production

PNAE – National School Feeding Programme

PNATER – National Policy for Technical Assistance and Rural Extension

PPA – Multi-Year Agricultural Plan

PRONAF – National Programme for Strengthening Family Agriculture

PRONARA – National Program for the Reduction of Pesticide Use

RL – Legal Reserve (Environmental Legislation)

SAF – Agroforestry System

SDGs – Sustainable Development Goals

SSFFAD – Special Secretary for Family Farmer and Agricultural Development

TNC – Transnational Corporations

USP – University of São Paulo

WDI – World Development Indicators Database

WFS – World Food Summit

ZEE – Ecological Economic Zoning

1

Introduction

In this introduction, my goal is to present my research through the lens of my personal experience and outline my motivation in pursuing it. My training was first in Ecology (bachelor degree) and then Landscape Ecology (master's degree). I then started to work in the third sector, specifically systematic conservation planning aiming the conservation of the Brazilian biodiversity. Through my professional experience, I was increasingly involved in projects to contribute with the sustainability improvement of the Brazilian agriculture. The agricultural sector is extremely important for the Brazilian economy and its development is embedded within a web of social and environmental threats and opportunities. Therefore, the sustainable improvement of the Brazilian agri-food system is intertwined with improvements in Brazilian social and environmental issues. My experience in this area revealed to me that, despite a few punctual advances, the sustainability agenda of the Brazilian agri-food system still has immense challenges to overcome. The **purpose and motivation** of the thesis is to contribute to identify these challenges and discuss possible solutions.

One aspect that was clear to me from my work and observations was that agricultural sustainability could not simply be concerned with production-side considerations. The concept of agri-food systems, embedded in social, cultural, economic and environmental processes, is thus a core foundational concept upon which I develop my research ideas.

Upon this basis, I was determined that the first step of progress towards sustainability depends on the establishment of a baseline, including indicators consistent with a broad definition of agri-food systems and their sustainability. The first **ambition and aim** of this thesis was thus to contribute to build this baseline and from there explore transition pathways for the sustainability of the Brazilian agri-food system, based on a broad perspective of agri-food systems and its sustainability.

Chapter 1

The structure of the thesis is organized to answer the concerns I held throughout my career about the Brazilian agri-food system. These concerns are delivered in five research questions or research gaps (see figure 1, chapter 3) presented below. The **first gap** I found in the literature is the lack of a broad yet clear concept of agri-food system, which should include its multi-functionality and multidimensionality and allow policy relevance and applicability of aims and outcomes (see chapter 2, Binder et al., 2010; Loiseau et al., 2012; IAASTD, 2009). The **second gap** is the lack of a broad and clear concept of sustainability in the agri-food system, taking into account multi-functionality, multidimensionality, policy relevance and applicability. The **third gap** is the lack of frameworks to assess agri-food system sustainability (specifically in Brazil) within the broad concepts identified in gaps 1 and 2.

Based on the context, challenges and gaps 1, 2 and 3, I complement the investigation of my concerns about the Brazilian agri-food system in the **fourth chapter** of my thesis, answering the following research questions: What is sustainability in agri-food systems? How can it be assessed? How can it be made applicable and relevant for actors in the field? In order to address these questions, first I develop a conceptual model of agri-food system (figure 2, chapter 3) adapted from Ericksen (2008).

The **fourth gap** in the literature is the lack of participatory approaches proposing pathways to achieve sustainability of the Brazilian agri-food system, based on a broad and clear concept of sustainability, with applicable policies and actions. Based on this gap, in the **fifth and sixth chapters**, I answer the following research questions: What do future visions for a sustainable Brazilian agri-food system by 2030 look like from the perspective of a group of practitioner stakeholders working in Brazil? What are the transition pathways to achieve sustainability in the Brazilian agri-food system for the two future visions created? In chapter 7, I propose alternative transition pathways and policy prescriptions to induce sustainability in the Brazilian agri-food system, summarising my interpretation of the most feasible and prominent aspects of the two previous transition pathways plus my own recommendations. Finally, in chapter 8, I summarises and contributions of my research, as well as research limitations and refinements for the future.

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Literature Review

I present the literature review in four sections. First, I highlight the mainstream perspective of the two major challenges of the agri-food system: secure access to adequate food for all people and reduced environmental impacts. Then, I explore the risks and limits of food security's hegemonic discourse to resolve these challenges. In the second section, I demonstrate the current food security discourse insufficiency to guarantee sustainability of agri-food systems. I advocate that it is necessary to adopt a clearer and broader concept of agri-food system (**gap 1** of the literature review) and its sustainability (**gap 2**) to understand the complexity of the system, its problems, causes and possible solutions. The third section demonstrates that current assessments and mechanisms to induce sustainability of agri-food systems also lack a broad perspective of the system, plus policy relevance and applicability of results (**gap 3**) and involvement of stakeholders (**gap 4**). Further, in this section I advocate that participatory approaches in addressing the first three gaps are promising mechanisms to more effectively assess agri-food systems, produce insights and induce pathways towards sustainability. The fourth section synthesises the Brazilian context.

2.1. Mainstream perspectives of challenges and solutions for the global agri-food system

According to several international agencies (FAO, 2017; OECD, 2015; Foresight, 2011; IAASTD, 2009) and researchers (Foley et al., 2011; Godfray & Garnett, 2014), the global agri-food system faces two major challenges: secured access to adequate food for all people and reduced environmental impacts. FAO (2016: 8) projects an increase of global food demand "by at least 60% above 2006 levels, driven by population and income growth, as well as rapid urbanization".

Mainstream solutions to increase food production are the increase of agricultural productivity and intensification of land use under the discourse of food security (FAO,

2017; Godfray & Garnett, 2014; Rockstrom et al., 2017; Foley et al., 2011; WTO, 2017), i.e. the physical and economic access to safe and nutritious food for all people (FAO, 1996). Food security crisis is used as a justification to further embrace the productivist mantra by some within the agri-food industry (Maye & Kirwan, 2013). Food security discourse mainly emphasizes technological improvements (mostly environmental and productivity) of conventional agriculture, which has controversial effects on the whole agri-food system, due to high dependence upon scarce external inputs, and social impacts. In addition, the intense focus on the increase of food production does not give enough attention to other issues within the agri-food system, such as inequality and power. Increases on agricultural productivity can not necessarily avoid the distortions of wider supply chain which continue to increase the risk of food insecurity (Horlings & Marsden, 2011). This reductionist perspective regarding food problems and how to solve them, thus prevents the understanding of inequalities and injustices within agri-food systems. As pointed out by Hopma & Woods (2014), global food security discourse feeds neoliberal arguments of free market and new technological revolution as solutions for the challenges of the agri-food system. However, although sufficient food is currently produced, 1/7 of the world population still do not have access to adequate food (FAO, 2017). Hunger is not a primarily result of a deficit of food production (Patel 2012). According to the author, "questions about hunger begin with questions about social and political configurations around power over food, rather than about the mere presence or absence of food in the vicinity of a hungry individual" (Patel, 2012, p. 1).

Agricultural productivity and intensification of land use are some of the most popular solutions for the increase in food production and strategies to deliver the widely accepted concept of food security (FAO, 2017; Godfray & Garnett, 2014; Rockstrom et al., 2017; Foley, 2011; WTO, 2017). Food security "exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996: paragraph 1). According to Jarosz (2011), the mainstream approach to food security, supported by international organisations, including the Food and Agriculture Organization (FAO), national governments (especially in the global north), and transnational agribusiness, advocates the increase of productivity through technological research, agricultural development and the market as solutions for

hunger and food insecurity. However, "meeting the projected increases in demand for food would not result in food security for all" (Tomlinson, 2013, p.85). According to the authors there is an inherent contradiction in these solutions to achieve food security because they do not address problems of climate change, diet-related ill health and hunger. Food security can be divided into two discourses, national and global. National food security is part of national security and geopolitical strategies, inducing political control of hunger, vulnerability and risk by the use of neoliberal forms of interventions (Essex, 2012). According to Hopma & Woods (2014), global food security is associated with the "scientisation" of food security; "presenting food security as a scientific problem rather than a political one" (for example, Godfray & Garnett, 2014; Rockstrom et al., 2017; Foley et al., 2011). While national food security risks the intensification of food insecurity in countries with limited agricultural resources, the discourse of global food security represents a return of the "green revolution", claiming the increase of production and technological innovation as a solution to the world's food problem. However, as Hopma & Woods (2014) argue both discourses advocate "western scientific and political technologies" as solution to achieve food security, discarding the "potential contribution of traditional peasant-centred farming in the global south". Thus, the technical perspective needs urgent and deep analysis, because, when these solutions are not linked to political perspectives, it becomes much more difficult to implement them. Consequently, the exclusive focus on technical arguments is used to feed a neoliberal discourse of the domination of science and corporations of the global north as stated by Hopma & Woods (2014) and Jarosz (2011). Another inconsistency of food security discourse is that it explores prominently conventional agriculture, which has serious limitations and risks related to the intense use of agrochemicals, biotechnology, and intensification of agriculture and raise of productivity etc. Lawrence et al. (2013) argues that productivist farming approaches are "incapable to bring about long-term production outcomes that will guarantee national food security". According to Dibden et al., (2013) if research funding continues to privilege agricultural biotechnology (GMO), farmers will risk losing control of seeds to private interests and the benefits of the agro-ecological paradigm. Another limitation is that yields are now rising slower than before. A longitudinal study of 174 crops carried out by the UN FAO and Monfreda (2008) showed that the global crop production increased by 56% between 1965 and 1985 and

by 20% between 1985 to 2005 (Foley et al., 2011). The high dependency on external inputs, such as pesticides, fertilizers, water and machinery raises concerns regarding improving agricultural productivity. According to FAO (2017), agriculture uses 70% of the water withdrawals in the world, whereas 40% of the world's rural population live in river basins classified as water scarce. Scarcity is also expected for phosphorus (phosphate), a non-renewable resource crucial for global crop yields, only obtained from mined rocks. Following current consumption trends, the primary rock phosphate reserves (in North America, North and South Africa, Russia and Southeast Asia) will be exhausted before the end of the 21st century (Smil, 2000; Zapata & Roy, 2004). In addition, conventional agriculture now depends completely on the chemical synthesis of nitrogen fertilisers. "Over 50% of the nitrogen in the global nitrogen cycle was synthesised industrially in the last 100 years" (Smil, 2001 apud Royal Society, 2009: 15) and phosphorus use tripled between 1960 and 1990 (Millennium Assessment, 2005a). Besides that, it will be required two percent of the total global energy for the synthetic nitrogen fixation by 2050 (Glendining et al., 2009). Higher input costs (mainly energy) were important drivers for the rising of food prices in 2008 (Dupont & Thirlwell, 2009). In general, if more chemical fertilizer and fossil energy per unit of output is needed to supply supermarkets, environmental changes like GHG emissions will certainly increase during the transition from "traditional" to "modern" value chains (FAO, 2017).

One of the main concerns of food security discourse is with the environmental impacts of food production. According to Foresight (2011), many systems of food production are unsustainable because they promote degradation or over-extraction of soil, water, biodiversity, fishing and are dependent on fossil fuels. Agriculture is also one of the main components of environmental change, mostly because of NOx (Nitrogen oxides) emissions from fertilizer use, CH_4 (methane) emissions from livestock and land use change. Land use change by the agricultural sector also has been the leading cause for biodiversity loss, mainly in developing countries (Foresight, 2011). This information corroborates the findings of Rockstrom et al. (2009) about the overstepping of the boundaries in three planetary systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle). As the authors explain, these boundaries "define the safe operating space for humanity with respect to the Earth system and are associated with the planet's biophysical subsystem or processes" (Rockstrom et al.,

2009: 472). Agriculture is one of the main reasons for the overstepping of these three boundaries.

According to Lang & Rayner (2015) the current food system is an example of a fundamental economy-health mismatch. The dominant neoliberal economic growth model leads the world to a pathway of sanitarianism that undoubtedly has brought important achievements to society such as health infra-structure (drains, water, houses etc) and modern medicine. However, there is a mismatch between ecosystem impacts and human progress. Sanitarianism is based on a business-as-usual techno-economic model that externalise health and environmental costs. The authors advocate the economic internalization of costs, since human existence cannot be separated from planetary or biological dynamics. The sanitarianism model also contains inherent risks as bad nutrition transition (from simple foods to high-calorie and ultra-processed foods) and over-production of food causing bad diet and ill-health, epidemic shifts (Lang & Heasman, 2004) as well as environmental damage (Rockstrom et al. 2009) by intensification farming (UNEP, 2009).

The impact of nutrition transition shows 1.5 billion people are now obese or overweight. Alongside the 0.9 billion people hungry in the world, this constitutes an alarming problem. Lang & Rayner (2015) states that to solve food system problem and tackle human progress, it is necessary to change the path from sanitarianism to ecological public health. Health should be the core of the conception of progress, replacing economic growth. Seen in this context, private interest even in public private partnerships (PPPs) is far from the best option to achieve social progress. On the contrary, "PPPs are neither neutral or benign, their growth made vast fortune, patents and intellectual property exploration". Private sector does not have incentives to address sustainability transitions, because the final aim is related to a collective good (sustainability) (Geels, 2011). The international agencies are powerless in face of the dominant power and are not "under pressure for a radical rethink". A modern public health movement has to reshape the conditions of existence reviewing existing goals, institutions and power. The ecological public health as movement, project and pathway should work to change values, a long term perspective of a practical vision of human progress. It is "characterized by different economic drivers and new patterns of work and wealth conservation, such as fossil fuel energy reduction, and conservation,

sustainable land use, full cost accounting (to internalize environmental, dietary and health costs), and low impact lifestyles"(Lang and Rayner, 2015: 1377).

Conceição & Mendoza (2009) classify the causes of agri-food system problems into internal and external factors. The authors say that some countries have to resuscitate their agriculture sectors "undertaking the appropriate public investments to boost these countries' agricultural sectors and rural economies". Citing Haiti's example, they mention that the key internal factor of agricultural sector's contraction in low-income countries is the opening up of the agricultural sector to international trade without guaranteeing investments to the sector's competitiveness. More than that, low-income households, which constitute majority of developing countries populations, are very vulnerable to the food insecurity through the volatility of food prices.

Among the key external factors affecting global food security in Haiti and developing world are the international trade in food, the inputs to produce food (higher oil prices and fertilisers), the environmental externalities linked to climate change and its effect on agricultural productivity, financial speculation, government policies, trends in biofuel development, lack of adequate investments in market-underpinning public goods, including critical regulatory and physical infrastructures, the thin global food trade market and the highly concentrated export supply. The high priority for the poorest part of the world is to guarantee adequate access to food, while for the developed world and fast-growing countries the urgency is to ensure the supply of energy.

Dupont & Thirlwell (2009) also mention the rise and volatility of food prices as one of the most significant challenges of food security. They explore the reasons for the 2008 food crisis citing a number of interrelated factors. On the demand side, they include population growth, growing developing-country prosperity which is responsible for a significant global shift in dietary patterns (nutrition transition), urbanisation, the escalating demand for biofuels, entry of new financial players into the world commodity markets (financial speculation), a falling US dollar and easy global monetary conditions. Hanjra & Qureshi (2010) follow the same arguments on demand side, considering that "a key challenge facing agriculture in the 21st century is how to feed a world with continuously growing and increasingly affluent population with greater meat demand". Dupont & Thirlwell (2009) and Hanjra & Qureshi (2010)

also agree regarding the key drivers which have impacted and will impact food production and the increase of food prices on the supply side. These are a fall in agriculture productivity, a growing scarcity of land and water, higher input costs (especially energy) and adverse weather conditions. Dupont & Thirlwell (2009) also mention government export restrictions affecting global food availability as an important supply driver, while Hanjra & Qureshi (2010) include a credit crisis that directly affects food production, a reduction in per capita arable land, a decline in investments in agricultural research. Dupont & Thirlwell (2009) and Hanjra & Qureshi (2010) stress the fundamental importance of a water policy reform to guarantee global food security. Hanjra & Qureshi (2010) state that international food trade promotes a virtual flow of water from producing and exporting countries to importing and consuming countries, enabling water and food security of the latter ones. They add that "food trade improves the access to food by increasing the food availability and lowering food prices for domestic consumers" (Hanjra & Qureshi 2010: 371).

According to Dupont & Thirlwell (2009) the prices of many staples will increase and show greater volatility than in recent decades. They state that "we have entered a period of increased uncertainty regarding the future trajectory of food prices" Dupont & Thirlwell (2009: 93). Despite these constraints, global food production is sufficient to meet global food demand; however, the authors highlight three grounds of pessimism to be dealt with: firstly, the uncertainties about the future price responsiveness of agriculture supply; secondly, the price responsiveness of food demand due to the reduced sensitivity of food consumption to changes in prices; and thirdly, governments acting to preserve a level of self-sufficiency in food for national-security reasons. On the top of these constraints, it remains uncertain to which extend climate change will affect agricultural yields. Following some estimates, if temperatures rises over 3°C the food prices could increase by up to 40% (Braun, 2007).

For Hanjra & Qureshi (2010) future food security depends on addressing interlocking issues to tackle climate change, conserving resources, developing and adopting new seeds, renewed investments in agriculture water, shoring up domestic food production, reforming international trade. However, they only consider it possible through greater international collaborations and strategic investments. Dupont & Thirlwell (2009) ponder that science and technology could help to mitigate these constraints by

extending current best practice where needed and by the improvement of current best practice through new technology. Acevedo (2011) also highlights the interdisciplinary research in a place-based modelling framework as an extraordinary tool to find solutions to improve food production, food security and environmental quality or identify impediments to achieve these aims due to human factors. The author indicate land productivity and water productivity as the major strategies to increase food production. The increase of land productivity means more food per unit area by using fertilizer and efficient cultivars.

However, intensified food production also implies in major environmental impacts, especially through the use of agrochemicals. There exists plenty of research evidencing the effects of agrochemicals on humans (Boxall et al. 2009; David et al. 2005) and ecosystems (Solomon et al. 2000; Schriever et al. 2007, Muir et al. 2004). The interdisciplinary research is crucial to understand those impacts using a variety of different approaches, scales and inferences, as made by Alderman *et al.* 2002 and Bernknopf *et al.* 2002. The increase in water productivity means more food per unit of water (Thenkabail & Lyon 2009). According to Brown (2005), food insecurity is intimately linked with water insecurity, and, as mentioned before, agriculture uses 70 per cent of global freshwater (Allouche, 2011, FAO 2017). Castillo et al (2007) point out that the improvement in water productivity contributes to food security as well as human health and income. In order to enhance the water productivity they propose empowering people to use water better, improving the governance of water resources, requiring investments in transportation, communication, extension services, credit, capacity building and education.

Allouche (2011) advocates that the complementary analysis of global food and water systems is essential. However he states that 'physical resource scarcity' is usually linked to the politics of inequality and is not in most cases the result of insufficient production or availability. Although some specialists view free global trade as necessary for food security (for example, Godfray et al., 2010), Allouche (2011) reminds us that international trade and technology for water and food security have limits. Free markets exclude the poorest, who have no influence in their structure and regulation as pointed by Anderson (2009). Allouche (2011) remarks that the concern and actions over food security have to be fundamentally about water. He warns that

"land grab concerns particularly agriculturally deficient, water short nations that depend on food imports to meet rapidly growing domestic demands". He also reminds that inequality is the main barrier for food/water security. "Increased food supply alone is not sufficient to reduce hunger" (Allouche, 2011:S7). Food/water security is not only linked to international trade but also to politics of inequality, gender and power and it must be addressed through political change.

According to Marsden et al. (2013) the agri-food system is dominated by corporate, retailer-led regulatory system. This regime is based on intensive agriculture and lacks advocacy of agri-food multi-functionality. However, there is an increase of new questions and visions from larger groups of stakeholders regarding to a wider and more integrated vision of security and sustainability for agri-food systems, including health and wellbeing. The author states that these questions can be addressed in a transition of agri-food system to Ecological Modernization (EM) into two main possible pathways: weak EM with dominant agri-food regime and strong EM with ecological agri-food economy. "Transitions may be viewed temporally as periods in which opportunity for change opens up within a system (i.e. a sociotechnical regime made up of dominant economic, industrial, political and scientific rules and assumptions) to produce something disconnected to earlier supporting structures, as the dominant system struggles to respond to surrounding (landscape) pressures" (Marsden et al. 2013: 124). According to Campbell & Dixon (2009), "a food regime comprised of a series of key relationships, often enshrined in rule-making and enforcing institutions (including imperial/national policy, trade policy, institutional forms of land-use/farming, company regulation, commodity complexes, labour relations, consumption relations in the industrial core)".

A transition to a weak EM prevails if the agri-food regime maintains the dominant frameworks and gives a marginal role for the new niche players and the development of products/process centres in technological and best practice means. Further than that, the dominant agrifood regime uses a technologically driven model ("sustainable intensification") to absorb the new landscapes and political pressure, liberalizes market, intensifies bureaucratic control and retains food as a commodity. Campbell (2009) states that the open up of space for an alternative regime structure does lead to modestly hopeful outcomes, usually less transformative than social movements hope. On the other hand, in a transition to a strong EM the dominant regime loses its

legitimacy and the niches becomes the new paradigm. The development of an eco-economical place-based reflexive governance promotes more rooted forms of sustainability, creating new policy space, vectors and frameworks and re-calibrating the power relations between production and consumption interests. "In a reflexive governance framework, cognitive and normative beliefs complement political administrative hierarchy and economic incentives as mechanisms of coordination" Feindt (2010: 1). Based on wider range of stakeholders, policy frameworks, sustainability discourses, new relationships between actors, more diverse supply chain and market governance arrangements the strong EM creates real structural and institutional changes. Sonnino et al. (2016) argues that this new emphasis on more integrated place-based and reflexive governance is important to solve the profound food security vulnerabilities. They conclude that "a progressive sense of place as a socially constructed and fluid entity is a key starting point to develop a more integrated multiscalar perspective that recognises food security as a complex 'polycentric' governance arena where different actors, knowledge and interests can converge to develop collective visions" (Sonnino et al. 2016:487).

2.2. Agri-food system needs a broad and clear definition of sustainability (gaps 1 and 2)

Some problems or drivers of the agri-food system are not clearly addressed by or are even contradictory to food security discourse, like inequality and power. Hunger and malnutrition are pertinent reasons for the need to increase the production of food. However, ensuring an increased supply of food does not guarantee the effective elimination of hunger. One seventh of the world population do not have adequate access to food, even though there is enough food produced to feed all people (FAO, 2017). The majority of the world's poor and hungry live in rural areas in developing countries (Foresight, 2011). Other human wellbeing elements such as safe water, sanitation, rights and culture are also important components for the quality of life of people living in these areas. Therefore, an important question is: if the world currently is failing to feed all humans, in spite of having enough food; why do we believe that the same policies to increase the production of food will feed everyone in an

overpopulated planet with scarcer natural resources? Efforts to increase production and productivity of food are essential; however more important is a deeper understanding of why there is hunger, malnutrition, inequality, etc., and the role agri-food systems can play in aggravating or improving these problems.

When food security discourse solely centres on the increase of food production, it masks the issues of inequality and injustice in agri-food systems, and endorses neoliberal arguments of free market and technical revolution. According to De Schutter (2017: 1), the UN special rapporteur on the right to food from 2008 to 2014, "producing too much food is what starves the planet". De Schutter (2017) states that general approaches to increasing food production are focused on technological advances and public policies, including providing subsidies to farmers to raise outputs and drive prices down. Nowadays, food systems are in the hands of powerful actors, using their power to oppose and veto transformation in the agri-food system. Taking into account Marsden et al. (2013)'s approach as reference, this means that the global agri-food system has followed a weak EM pathway. Fuchs et al. (2015) argue that power is essential to understanding what drivers and what barriers exist against changes to sustainability, and help to identify potential points of intervention. The authors state that studying power, "uncovering the hidden and exposing the inequitable is a civic obligation, a sustainability imperative and a justice prerequisite" (Fuchs et al., 2015: 9). Fuchs et al. (2009) conclude that large retail power fosters inequality and poverty for many small and medium-scale farmers, and threatens the livelihoods of small local retailers in developing and developed countries. The authors recommend the prevention of the emergence of monopsony and oligopsony power and the participation of NGOs and farmers from developing countries in the definition and development of private standards. Such recommendations echo Hopma and Woods' (2014) arguments that technical solutions are not enough to solve agri-food problems, because the decisions to act are primarily political.

Food sovereignty emerges as an alternative discourse recognised as the "South's political efforts against the neoliberal reorganisation of its agricultural system" (Germann, 2009 apud Riol, 2017: 21). Food sovereignty "is the right of peoples to define their own food and agriculture; to protect and regulate domestic agricultural production and trade in order to achieve sustainable development objectives; to

determine the extent to which they want to be self-reliant; to restrict the dumping of products in their markets, and; to provide local fisheries-based communities the priority in managing the use of and the rights to aquatic resources. Food sovereignty does not negate trade, but rather, it promotes the formulation of trade policies and practices that serve the rights of peoples to safe, healthy and ecologically sustainable production." (Peoples' Food Sovereignty Statement, 2017: 1). Hopma & Woods (2014) state that food sovereignty is a politicised concept, compared to the depoliticised discourse of global food security. It also differs from the discourse of national food security by empowering the people of the nation and farmers, instead of nation states. It is both a concept and a bottom-up movement that aims for a transformation in the global agri-food system, in terms of equity, social justice, democracy, right to food and ecological sustainability (Riol, 2017; Hopma & Woods, 2014). The final recommendation of De Schutter (2014: 20) to the UN was "understood as a requirement for democracy in the food systems, which would imply the possibility for communities to choose which food systems to depend on and how to reshape those systems, food sovereignty is a condition for the full realization of the right to food". Food sovereignty embrace the language of rights, that people must have the right to define their own food and agricultural system and their rights to the resources to do so must be protected (Walsh-Dilley et al., 2016). In 2014, FAO agreed to begin discussing food sovereignty as opposed to food security (Nicastro, 2014), however, food security is still the vastly hegemonic discourse of scientists, national and international agencies and their policies.

On the other hand, Clapp (2014) states that the oppositional frame of food sovereignty and food security is manufactured and not real. She does not criticise the food sovereignty agenda, but the frequent presentation of the concept of food sovereignty as being in direct opposition to the concept of food security. She states that the concept of food sovereignty is normative and seeks to support the political mobilization around peasant rights. The concept of food security is more descriptive than normative, and therefore it is inappropriate to associate it with the mainstream discourse of neoliberal agenda. She argues that the concept emphasizes access as a central component, therefore it cannot be conflated with productionist views. The fact is that the current mainstream political agenda to fight hunger prioritizes production rather than access. More effort should be directed to the critique of the inequities of a free trade agenda,

rather than trying to explain its links to the concept of food security. Maye & Kirwan (2013) recognizes that the concept of food security is clearly problematic, however, its policy relevance and social currency are strong justification to not abandon the term too readily. Clapp (2014) advocates that both food security and food sovereignty are complementary and useful concepts to debate, as well as formulate policies to address the challenges of the global food system. Even Via Campesina initially considered food sovereignty as a "precondition to genuine food security" (Patel, 2009). The challenge is to build a constructive and meaningful dialogue between the two approaches and respective ideological camps.

Sonnino et al. (2016), in turn, highlight that the narratives of food security changed over time. Initially it was based on productivist approaches, i.e., the application of western science by large agricultural producers from industrialised countries, their national governments and transnational corporations. Over time, small farmers and their traditional agro-ecological practices were included with the emergence of the sustainable intensification approach and the influence of food sovereignty discourse. The consumer-citizens began to take part of food security narrative when food started to be seen as human right. The livelihood security framework emphasises on access and right of individuals to nutritious food. Finally, "notions of food democracy, food citizenship and community food security have contributed to progress more place-based conceptions of shared food rights" (Sonnino et al., 2016, p:484).

I advocate that food security and food sovereignty discourses, more than complementary approaches as pointed by Clapp (2014), are both essential elements for the final equation to bring sustainability to agri-food systems. The mainstream concern about the increase of food production and its predictable environmental impacts is extremely pertinent and requires research and policy attention. However, over-stressing or focusing narrowly on these two elements may mask other significant drivers and problems of the agri-food system and the possibility of a broader perspective of sustainability. The current food security concept and state of art, that represent these concerns, is far from delivering solutions for a broad sustainability of agri-food systems. Food sovereignty has shone a light on food security vulnerabilities, inconsistencies and incoherencies and should be strongly incorporated to the sustainability agenda. International agencies and agreements, for example the Millennium Development Goals (MDGs); Sustainable Development Goals (SDGs)

and Aichi biodiversity targets, are natural places to induce sustainability changes in the agri-food system; however, they are still far from reaching a broad perspective of sustainability and are weakly implementable. Aichi targets, for example, present goals for the protection of biodiversity and ecosystem services, considering traditional communities as important protagonists, however the implementation of this environmental agreement does not have the same priority as the economic agenda. The SDGs replaced the MDGs in 2015 with the task to lead a common agenda to achieve sustainable development. According to a science review made by ICSU, ISSC (2015), the SDGs represent a major improvement on the MDGs, especially in addressing key systemic barriers to sustainable development such as inequality, unsustainable consumption patterns, weak institutional capacity, and environmental degradation, which the review argued were all neglected by the MDGs. Six essential elements are used to deliver the SDGs (UN 2017); dignity, prosperity, justice, partnership, planet and people in 17 goals and 169 targets. However, the SDGs do not have a narrative of change or an ultimate end, and do not identify which are the agents that will deliver the changes alongside governments (ICSU, ISSC 2015). Further, the SDG focus on the achievement of minimum resources, rights and dignity to all people, however, paradoxically, do not establish goals and targets to restrict the maximum concentration of power or resources, which is the ultimate cause of inequalities and injustice. Goal 2, to "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" for example, should be targeted in favour of vulnerable small-scale producers (ICSU, ISSC, 2015). However, following the standard of international agencies, the SDGs embrace the global food security concept, which privileges free market and neoliberal discourses. Ziegler, the UN rapporteur from 2002 to 2008, states that the "neoliberal agricultural and food security policy is increasingly 'under the thumb' of the World Trade Organization (WTO), the International Monetary Fund (IMF) and the World Bank, and created for the interests of agribusiness and transnational corporations (TNCs)" (Ziegler, 2013 apud Riol, 2017: 3/4). According to the author, even FAO is "largely absent from the battlefield. It has been bled dry, gutted" (Ziegler, 2013 apud Riol, 2017: 4). Therefore, the policy and actions of UN, FAO and consequently the SDGs are restricted to reforms to the system, and do not guarantee the implementation of a broad perspective of sustainability.

The agri-food system needs a broad and clear definition of sustainability, which includes and exceeds the concepts of food security and food sovereignty, taking into account multi-functionality, multidimensionality, policy relevance and applicability. The definition has to be able to deal with the complexity of agri-food systems drivers and factors, such as demand and supply side factors (Dupont & Thirlwell 2009, Hanjra & Qureshi 2010), governance (Hopma and Woods 2014, Jarosz 2011), place based governance (Marsden et al., 2013, Sonnino et al. 2016) health (Lang and Rayner, 2015), trade (Conceição & Mendoza 2009), power (Fuchs et al. 2015), water and natural resources scarcity (Acevedo, 2011, Allouche, 2011) etc.

Foresight (2011) concludes that the agri-food system needs a complete redesign to bring sustainability to the fore. However, what is sustainability in agri-food systems? How can it be assessed? How can a complex concept such as sustainability be applied to a complex topic like agri-food systems in a way that brings knowledge and is relevant for actors in the field? This research adopts two key aspects of sustainability: multi-functionality and multidimensionality. Some authors argue that it is necessary to take into account dimensions of sustainability such as biodiversity, the provision of ecosystem services, land and water use, and social and cultural identity (Hammond et al., 2013; Agostinho & Ortega, 2012; Agostinho & Ortega, 2012a; Silva Lora et al., 2011; Loiseau et al., 2012). One potential improvement in the way sustainability is measured could be an integrated analysis of a farm, a set of farms or a territory, taking into account what some authors call the multi-functionality of agriculture (Kamp et al., 2013; Loiseau et al., 2012; IAASTD, 2009; Fernandes & Woodhouse, 2008; Risku-Norja & Maenpaa, 2007; Potter & Tilzey, 2007). Following the IAASTD (2009: 565), the concept of multi-functionality "recognizes agriculture as a multi-output activity producing not only commodities (food, feed, fibres, agrofuel, medicinal products and ornamentals), but also non-commodity outputs such as environmental services, landscape amenities and cultural heritages".

2.3. Improvement of assessments and mechanisms to induce sustainability of agri-food system (gaps 3 and 4)

In order to achieve sustainability in agri-food systems it is necessary to improve policy relevance and the applicability of results, and to involve stakeholders in assessments and mechanisms. Binder et al. (2010) state that sustainable assessments in agriculture highlight environmental and technical issues, while ignoring other elements of sustainability such as the social and economic aspects, the multi-functionality of agriculture and the applicability of results. Conversely, since the selection of sustainability indicators is essentially a political process (Rudd, 2004; McCool & Stankey, 2004), there may be opportunities for the involvement of society in the definition and applicability of these tools for human wellbeing, food security, food sovereignty and environmental quality. A variety of methodologies is used to assess agri-food sustainability, focusing mainly on the environmental and technological aspects. However, it is urgent to explore and better understand the sustainability of agri-food systems and how to assess it. The answer is neither simple, nor unique. According to Heller and Keoleian (2003), the efforts to address these challenges have focused on the sustainability aspects of agricultural production, strongly neglecting the entire structure of the agri-food system. There has been a growing focus on bottom-up approaches led by end-users, consumers and citizens aimed at a systemic change, aspects which also have been neglected (Quist, 2013). According to Quist & Vergragt (2006), approaches aimed at systemic change should encompass three different features: a broad variety of stakeholders; a broad set of social, economic and environmental considerations; and a broad understanding of supply chains as encompassing production and consumption systems.

In order to understand the whole sustainability it is necessary not only to use frameworks that integrate all aspects of sustainability, but also to connect it to policy in order to enhance the applicability of these frameworks. A huge international effort has been made to create a baseline agreement for the concepts and goals necessary to achieve planetary sustainability. The Millennium Development Goals (MDGs) and the Aichi Biodiversity Targets (Aichi Targets) are two examples that should be linked to assessments and mechanisms to achieve the sustainability of agri-food systems. The Aichi Targets are the strategic plan from the United Nations to save biodiversity and

thereby also contribute to human wellbeing and poverty eradication (UN, 2014). The signatories have developed national action plans to implement the strategic plan for Biodiversity 2011-2020 which are evaluated and monitored by a set of indicators. The MDGs are a partnership between developed and developing countries "to create an environment – at the national and global levels alike – which is conductive to development and elimination of poverty" (UN, 2017: paragraph 12). Similar to the Aichi Targets, the MDGs use indicators to evaluate and monitor the status of human sustainable development and sociobiodiversity conservation. The MDGs recommend that all indicators should be disaggregated by sex and urban/rural as much as possible. The first phase of the MDGs ended in 2015, when a new stage of the partnership was agreed with the Sustainable Development Goals (SDGs). The majority of the MDGs and Aichi Target indicators are similar to the indicators proposed by the literature regarding the sustainability of the agri-food system and are highly suitable to be applied to agri-food system assessments.

2. 4. Brazilian context

Brazil is a major player in the global economy and much of its dividends come from the agribusiness. In 2012 Brazil became the seventh largest economy in the world, and has moved up to the rank of "upper middle-income economy" (WDI, 2013). Brazil is very rich in agricultural resources. It has the fourth largest agricultural land area in the world of 2 750 km^2. It also has the world's largest freshwater resources and the largest reserves of potentially cultivable land (2012 data from OECD, 2015; WDI, 2013). Primary agriculture contributed 5.3% (in 2012) to Brazil's GDP (World Bank, 2017). Nevertheless, the participation of the whole agribusiness supply chain (including inputs, processing and retailing) in the total Brazilian GDP was 22.54% (in 2013) (CEPEA/USP, 2017). Primary and processed agricultural products accounted for 41.3% (in 2013) of exports (MAPA, 2016, 2016a) and were a large source of foreign currency earnings, which more than offset other trade deficits (OECD, 2015). For 2015, the exportation of Brazilian agribusiness reached 88.2 US Billion dollars, while the import of agricultural products was 13.1 US Billion dollars, giving a trade balance of agribusiness of 75.1 US Billion dollars (MAPA, 2016, 2016a). The world demand

for agricultural commodities mainly comes from developing countries due to continued but slowing population growth, rising per capita incomes and urbanization (OECD/FAO, 2015). Importing nations will become more dispersed over a large numbers of countries, exports of agricultural commodities will become more concentrated with few countries (including Brazil). The result of just a few countries supplying global markets for a few commodities is a risky scenario in terms of global food security. This is both due to the threat of natural disasters in these countries, or the adoption of disruptive trade measures, such as commodities barriers or subsidies. OECD/FAO (2015) alert that there is a high probability of at least one shock to international markets in the coming decade, following historical variations in yields, oil prices and economic growth. The export of agricultural commodities brings important dividends to the Brazilian economy; however, it is a risky strategy to focus such a big part of its economy in a sector with high levels of wealth concentration, low value added products and high dependency of external inputs, especially agrochemicals. Ioris (2017) states that the true extent of agro-neoliberalism's success is highly questionable because the "wider business community have become highly dependent on the export of primary commodities". In addition, agribusiness leaders become disproportionately influential in politics, advancing conservative agendas and secure further concessions from the governments (Ioris, 2017). As stated by OECD (2015) and Padua (2004), the Brazilian agricultural policy rationale, objectives and programmes divides into commercial agriculture, represented by large and medium-scale farms, and small-scale family farming. The policy implementation of these two approaches is institutionally divided between the Ministry of Agriculture, Livestock and Food Supply (MAPA) and the previous Ministry of Agricultural Development (MDA) (the current Special Secretary for Family Farmer and Agricultural Development – SSFFAD, see chapter 6), respectively. According to OECD (2015) the policy objective for commercial agriculture is to boost production in the sector, while making it more technologically advanced and "sustainable". Small-scale family farming policy has an equity rationale and aims to empower the rural poor to generate better incomes. Small farmers' policy focus on providing rural poor access to agricultural land, financial resources, and knowledge and skills necessary to undertake farming or other rural activities.

MAPA's mission is to promote the sustainable development and the agribusiness competitiveness for the benefit of Brazilian society. Its vision is to be recognised for quality and agility for implementing policies and providing services towards the sustainable development of the agribusiness. For MAPA, sustainability takes into account socio-economic development and respect to the natural resources balance and limitations (MAPA, 2017). The Brazilian Agricultural Research Corporation (EMBRAPA) is a public corporation attached to MAPA and is extremely important and central to the development and consolidation of agribusiness in Brazil. Its mission is to provide research, development, and innovation solutions for the sustainability of agriculture and for the benefit of Brazilian society (EMBRAPA, 2014). EMBRAPA, through its strategic intelligence system (Agropensa), produced a document "Vision 2014-2034" to subsidise the formulation of strategies for research and innovation and to assist the formulation and improvement of public policies for the advancement of Brazilian agriculture and cattle ranching. According to this vision, future challenges should be tackled with technologies that are more efficient to supply the food demand, fibre and energy for the industry, and surplus for exportation in order to guarantee global food and energy security (EMBRAPA, 2014). This vision works in the logic of the supply chain.

The MDA mission was to promote policy for the development of the rural Brazil, democratization of the access of land, the territorial management of land structure, productive inclusion, increase small-scale family farmers income and peace in rural areas, contributing to food sovereignty and socio-economic and environmental development. Its vision was to be recognised nationally and internationally as a fundamental stakeholder to build an equitable rural area, with more opportunities of income and life, more human with social and productive inclusion and respect to the environment (MDA, 2016). The National Institute for Colonization and Land Reform (INCRA) is still an important institution subordinated to the SSFFAD, whose mission is to execute land reform and national land planning. Other ministries that also have some influence on the Brazilian agri-food system are the Ministry of Social Development and Fight of Hunger, Ministry of Health, Ministry of Fisheries and Aquaculture and Ministry of Transport. MAPA has the most powerful influence on the Brazilian agri-food system and its vision prevails in national policies.

OECD (2015) highlights the three main instruments used to achieve Brazilian agricultural policy objectives: price support (a minimum guaranteed prices policy), insurance support (mitigation of fluctuations in farmers' incomes) and concessional credit. Credit support is the most important instrument. The mechanization of agriculture has emphasised credit, however, since mid-2000s, new technologies and sustainable agricultural practices have also been supported. Credit predominantly goes to commercial producers. In 2013-2014, they received 90% of credit allocations, while the small-scale family farmers received 10% (OECD, 2015). Investment credit for small-scale family farms are available mainly under the umbrella of the National Programme for Strengthening Family Agriculture (PRONAF). Increasingly, environmental sustainability criteria, for example the respect of zoning rules have been required to access credits for both commercial and small scale farming activities. However, the environmental policies also benefit primarily large-scale producers, as stated by Di Gregorio et al. (2016) in the case of the ABC plan (a plan for the mitigation and adaptation of climate change for low carbon emissions agriculture).

The economic success of the Brazilian agribusiness sector is controversial because it has resulted in the concentration of land ownership, income and power. According to the last Agricultural Census (2006), units of less than 20 hectares constitute two-thirds of the total number of farms in Brazil, but occupy less than 5% of farmland. On the other hand, there are holdings of over 1,000 hectares accounting for only 1% of the total number of farms and concentrating 44% of farmland (OECD, 2015). Some authors are very critical about the Brazilian agri-food system model. Although Brazilian agriculture has seen extraordinary economic growth and technological development, it is important to recognise that the Brazilian agri-food system is culturally and environmentally unsustainable. This was the conclusion reached by five researchers (two from academia and one industry, one social movement and one NGO representative) in an analysis of the sustainability of Brazilian agriculture organized by Padua (2004). The authors stated that the Brazilian agriculture model generated serious socio-environmental impacts: reduction of job positions, social and technological marginalization of small-scale family farmers, diseases due to pesticide contamination and natural resources depletion, including soil degradation and biodiversity loss for deforestation or for agrochemical contamination and other inputs. Martins (2014) states that agricultural modernization caused a social backlash in

Brazil, disrupting traditional societies with relatively low economic efficiency. According to Padua (2004), a redirection of public policies is crucial to achieve sustainability in the Brazilian agri-food system. The strategies agreed by representatives from NGO, academia, industry and MST (Landless rural workers' movement) (Padua, 2004) were: incentives for the reduction of agrochemical inputs; diversification of production; dissemination of State programmes about watershed management; curricular reformulation of agronomy courses; reorientation of research and extension in agriculture and cattle ranching, focusing on agroecosystem management, and not on a specific product; valorisation and re-qualification of the rural labour force. Income distribution in Brazil is one of the most uneven in the world (OECD, 2015), especially in rural areas (IPEA, 2014). The distribution of wealth in Brazil remains one of the most uneven in the world. In 2012, the share of national consumption of the poorest quintile was 3.4%, whereas the share of the richest quintile was 57.1% (IPEA, 2014). According to data from World Development Indicators, 2014 the highest earnings of 10% of the population accounted for 42% and the lowest earnings of 10% responded for 1%. This inequality is even greater in rural areas. The 30% incidence of poverty is more than the double that in urban areas.

The use of agrochemicals in Brazil is a very critical issue as well. According to ABRASCO (2012), in 2008, for example, the agrochemical market increased 190% in Brazil, while the world market increased 93%. In the same year, Brazil surpassed the USA and assumed the position of the world's largest agrochemical market. In 2010, Brazil had a share of 19% of the global market. Instead of promoting incentives for reductions in the use of agrochemicals, there are important stimulus to its consumption through the reduction of prices and the exemption of agrochemical taxes (Machado, 2012). The aggravating factor is that from the 50 agrochemicals most used in Brazil, 22 are forbidden in the European Union (ABRASCO, 2012). According to the ABRASCO (2012) report, if the current agrochemical scenario is worrying, the likelihood is that it will worsen in the coming years.

Neither of the two strands of the political dichotomy of the Brazilian agri-food system is consistent with the perspective of sustainability in the international agreements to which Brazil is signatory. Therefore, a substantial improvement towards a sustainable agri-food system is unrealistic without the strong alignment of Brazilian policies to

sustainability concepts, aims, targets, and indicators. MAPA/EMBRAPA's vision takes market and technological innovation as the central force to bring sustainable development and benefits to the Brazilian society. SSFFAD gets closer to a broad sustainability vision, counting on policies to bring equity, food sovereignty and respect of the environment, in a logic of territorial management. However, SSFFAD's vision is still incomplete. Both visions lack a systematic characterization of agri-food systems (like the conceptual model develop by Ericksen, 2008, see chapter 3) in a broad perspective of sustainability as advocated by this research (see chapter 3).

Brazil is playing an increasingly greater role as one of the world's main food producers and exporters. Strong support from national public policies is an important factor, which can explain the positive tendency for the increase of the Brazilian agribusiness (MAPA, 2015). In addition to domestic and external rise of demand for food commodities (OECD, 2015). Government tend to remain policies to incentivise rural credit, commercial support and rural insurance with orientation to the market. The Agricultural and Livestock Plan from MAPA (2015a) states that exports from agribusiness increased four-fold in the last decade, reaching 100 billion dollars in 2013, with emphasis on the soybean complex (33.2 billion dollars), meat (16 billion dollars) and the sugarcane complex (12.8 billion dollars). These three products accounted for 62% of the sector's exports. Apart from wheat, Brazil is self-sufficient in food production, which contributes to the Brazilian balance of trade.

According to a report published by MAPA (2015a) about projections for Brazilian agribusiness between 2014/2015 and 2024/2025, the most dynamic products will be soybean, wheat, maize, rice, coffee, sugar cane, beef, pork and chicken meat, cotton, apple, melon and cellulose. Growth in production will come mainly from the increase in productivity, rather than the addition of new land. The crop area will expand from 71 million hectares in 2014/2015 to 82 million in 2024/2025, an increase of 11 million hectares, approximately the size of Bulgaria. Internal markets will be the main destination for meat production in 2024/2025, 64.5% of chicken production, 74.6% of beef and 82.8% of pork (MAPA, 2015a).

According to OECD/FAO (2015), global food prices are predicted to decline over the next 10 years; however, they will remain at a higher level than in the years preceding the 2007/2008 price spike. The slowing increase in demand for food will come mainly

from developing countries based on slowing population growth, rising per capita incomes and urbanization. Rising incomes will be reflected in dietary changes, increasing the consumption of animal protein. For this reason, prices of meat tend to be higher than prices of crops. In addition, the increase in demand for meat will pressure prices for coarse grains and oilseeds used to feed animals. The slowing increase in demand for commodities and lower oil prices will result in downward pressure on prices. Lower oil prices also will make the first generation of biofuels not profitable. Even so, the production of sugar-based ethanol in Brazil will increase incentivized by the mandatory blending ratio in gasoline and the provision of tax incentives by the government.

Despite the slower growth in domestic and international demand and prices declining from recent peaks, OECD/FAO (2015) project that the outlook for Brazilian agricultural is favorable through the 10 years analyzed (2016-2025). In this period, the exchange rate for the Brazilian real (BRL) relative to the USD is expected to depreciate, making Brazil's exports more competitive in the world market. In addition to opportunities for Brazilian commercial agriculture, growth in demand also will provide opportunities for small-scale family farmers for example those producing coffee, tropical fruits and horticulture (OECD/FAO, 2015). The report highlights that agriculture will continue to play an important role for Brazil's economy and an opportunity for social inclusion, food security and technological development. However, the report considers that improvements in productivity and sustainability are essential in this process. The National Plan for Sustainable and Solidarity Rural Development 2015 organized by the previous MDA advocates a transition towards an agroecological production model applied by small-scale family farmers. It suggests that the sustainability of the prevailing agricultural development model needs to reformulate its current policies. Brazil had a strong solidarity economy movement that supports this vision by strengthening the development of sustainable production and consumption patterns. Since 2003, Brazil has a National Secretary of Solidarity Economy to promote ethical and sustainable small businesses. This has led to 1,7 million people being employed in 22000 solidarity enterprises in 2007. The solidarity economy movement gains increasing prominence in the current face of neoliberal politics (Singer, 2009). Regarding the agri-food system, the most prominent actors of

solidarity economy are cooperatives from the landless rural workers movement (MST).

Food security in Brazil

According to Sonnino at al. (2014), the earliest institutional responses to the problem of hunger and malnutrition in Brazil was made in the early 1940s with the creation of the Social Security Food Service (**SAPS**), subordinated to the Ministry of Labour. The SAPS sought to provide food aid for workers, food education and low-cost outlets for staple food until 1967 when it was extinct (Arruda & Arruda, 2007). During the dictatorship between 1964 and 1984 the government emphasized the development of national market (Sonnino et al. 2014). In this period, Brazil introduced a range of tax and credits for processed agricultural products to favor industry over agriculture (Sonnino et al 2014), while subsidizing export products (e. g. soy, meat) over domestic staple foods (Graham et al 1987). In 1972 the Food and Nutrition National Institute (**INAN**) was created to support the government with the formulation of the food and nutrition national policy, propose and elaborate the Food and Nutrition National Program (**PRONAN**) and centralize all food and nutrition activities (Arruda & Arruda, 2007). According to the authors, the **PRONAN I** was created in 1973 and interrupted in 1974 because of difficulties of implementation. From 1976 to 1989 the PRONAN II was established with strong intersectoral characteristic influencing at the same time food production, commercialization and consumption (Burlandy, 2009). The PRONAN II main programs were the basic supply program, the project for basic foods procurement in low rural areas, the popular nutrition program and the national company for food supply. Burlandy (2009) highlights that during the **PRONAN II**, **INAN** was unable to consolidate a policy for the sector and establish itself as a coordinating instance and interfere with other governmental food programs, such as **PAT** and **PNAE** (Burlandy, 2009). The Worker's Food Program (PAT) was leaded by the Ministry of Labor by 1976, structured as public private partnership with the objective to supply worker's basic needs on food and health (Lemos & Moreira, 2013) through a tax incentive, enabling companies to provide meals to workers (Arruda & Arruda, 2007). The National School Feeding Program (**PNAE**) was launched in 1979

by the Ministry of Education (Sonnino et al. 2014) providing lunch for schoolchildren aged 7 to 14 years old (Arruda & Arruda, 2007).

The late 1980's was marked by an intense political dispute for the democracy and rights during the transition from military dictatorship to civilian rule. Civil society movements were essential to this transition, which included a broad social movement against hunger and for food and nutrition security (Abrandh & Oxfam, 2012) and rural and land issues such as landless rural workers' movement (MST) (Wolford, 2008, Schneider et al., 2010). The 1988 Federal Constitution is one of the most important results of all fight for **democracy** and **social participation** (Abrandh & Oxfam, 2012), invigorating a new process of administrative and **political decentralization** in Brazil (Sonnino et al. 2014). As part of the political decentralization, in 1994 the National Conference for Food and Nutrition (**CNSAN**) was held and the First National Council for Food and Nutrition Security (**CONSEA**) was established (Sonnino et al. 2014). The First CNSAN was the final assemble to discuss, emend and approve a political report called 'Statement in defense of a national food security policy'. The report reflects the concerns and yearnings of the Brazilian society which seeks solutions to end hunger, misery, lack of citizenship, the social exclusion broadly discussed in hundreds of municipal conferences, 26 state conferences, public companies and university committees (CONSEA, 1995). CONSEA was re-assembled during the Lula's government in 2003 (Rocha, 2009). It is a tool of articulation between government and civil society in proposing guidelines for actions in the area of food and nutrition, directly advising the Presidency of the Republic on the formulation of policies and guidelines to guarantee the human right to food (FAO/MMA/ABC, 2013). It seeks to balance the unequal relationship between State and civil society organizations adopting a criteria of representation of 2/3 of the National CONSEA members coming from civil society and 1/3 from different government sectors (Abrandh & Oxfam, 2012). CONSEA developed several proposals and initiatives like Food Procurement Programme (PAA) and the increase in allowances for the National Programme of School Feeding (PNAE). However, the most important accomplishment of CONSEA has been the elaboration of the National Law on Food and Nutrition Security (LOSAN) passed by the Brazilian Congress in 2006. The law institutionalize the Right to Food as a matter of public policy and an obligation of the state (Rocha, 2009). The law also "establishes the national Council as a permanent state institution,

with an elected president from civil society and the mandate to develop a National System for Food and Nutrition Security (SISAN)" (Rocha, 2009, p. 61). SISAN defines that in order to guarantee food and nutrition security the production of food has to follow practices to promote health, respecting cultural diversity and environmental, economic and social sustainability (FAO/MMA/ABC, 2013). According to FAO/MMA/ABC (2013), the mentioned laws and government structures give the opportunity to CONSEA to oppose the excessive use of agrochemicals in favor of agroecological production. CONSEA is a key actor in the drafting of relevant legislation on food security (Sonnino et al. 2014). According to the authors, CONSEA is part of a turning point on food security policies in Brazil in 2003, after the election of President Lula, when the government launched the Zero Hunger program among other initiatives. These changes were made by a collective construction within SISAN from civil society and government, allowing the inclusion of the right to a healthy diet and food and nutrition security into the Brazilian Constitution. The core element for food and nutrition security implementation in this period is the participation of civil society both in the formulation of public policies and in actions of public nature (Abrandh & Oxfam, 2012). The participation of social movements was crucial to forge the definition of food and nutrition security approved at the Second National Food and Nutrition Security Conference (CNSAN) in 2004, enshrined in the framework law passed in 2006 and regulated in 2010 through Presidential Decree (Abrandh & Oxfam, 2012). "Food and nutrition security is the realization of the right of all to regular and permanent access to quality food in sufficient quantity, without compromising access to other essential needs, based on nutrition practices that promote health, respect cultural diversity and are socially, economically and environmentally sustainable" (CONSEA, 2006, pg. 4, author's translation)

According to Abrandh & Oxfam (2012) this official definition and all government laws and frameworks puts food and nutrition security as a public, strategic and permanent goal and at the core of Brazil's development options. Firstly because the noun nutrition links the socio-economic and health and nutrition approach evolving the concept of food security to an inter-sectoral perspective. Second by unifying two inseparable dimensions into a single concept – food availability and the quality of this food, allowing the criticism of conventional models of production and consumption and the references to healthy food. Third because it reflects two fundamental

principles: the human right to adequate and healthy food and food sovereignty, distinguishing this approach from common use of the term food security by governments, international organizations and food corporations. The human right to adequate food is enshrined in the framework law: "Adequate food is a fundamental human right, inherent in the dignity of the human person and indispensable for the realization of the rights enshrined in the Brazilian Constitution, and the government should implement the policies and actions that may be necessary to promote and ensure the food and nutrition security of the population" (CONSEA, 2006, pg. 3, author's translation).

The following CNSANs, i.e., the Second (2004), Third (2007) and Fourth (2011) continuously have recommended the need to create new forms of social participation, with special attention to local agro-ecological systems and ethnic communities, as well as addressing new challenges like obesity (Sonnino et al, 2014). According to the authors the reflexivity in Brazil promotes policy adaptation to change the dynamics of the national agri-food system. Three elements are essential for the success of the Brazil's social policy frameworks for food and nutrition security, they are rights-based, intersectoral and involve participatory citizen engagement (Santarelli et. al, 2018). In addition to the policies and frameworks exposed here, some other are also consequence and strength the reflexive governance placed in Brazil, such as the National Policy of Technical Assistance and Rural Extension (PNATER), the National Plan for the Promotion of the Socio-biodiversity Product Chains (PNPPS), the National Council for the Sustainable Rural Development (CONDRAF). From 60s to 80s, the focus of the ATER (Technical Assistance and Rural Extension) was on the massive transfer of technological packages. Nowadays, it is based on an informal multidisciplinary and interdisciplinary education, focused on participatory methods offering means and knowledge to beneficiaries in order to build new forms of knowledge and participation for production, processing and commercialization (FAO, 2013). The National Policy of Technical Assistance and Rural Extension (PNATER) was institutionalized in 2010 to stablish the principles and objectives for the implementation of the ATER, i.e., promoting the sustainable rural development, social inclusion, food and nutrition security and environmental conservation (FAO/MMA/ABC, 2013). The National Plan for the Promotion of the Socio-biodiversity Product Chains (PNPPS) was elaborated by the Ministry of Agrarian Development, Ministry of Social Development and Fight

Against Hunger and Ministry of Environment in partnership with other governmental institutions, civil society and private sector. The main objective of the Plan is to develop integrated actions for the promotion and strengthening of socio-biodiversity product chains, adding value and consolidating sustainable markets (MDA/MMA/MDS, 2009, author's translation). The National Council for the Sustainable Rural Development (CONDRAF) is composed of half governmental and half civil society members with to propose guidelines for the formulation and implementation of public policies to promote the sustainable rural development, land reform and family farming (MDA, 2019).

The mentioned and other reflexive frameworks changed the Brazilian approach about food and nutrition security with the turning point of governance made on President Lula's government from 2003 (Rocha, 2009, Abrandh & Oxfam, 2012, Sonnino et al. 2014, Tomazini & Leite, 2016). Several policies were created or improved based on the new approach, some of them are:

- National Programme for Family Agriculture (PRONAF) – financing projects to generate income to family farmers and those coming from land reform settlements (MDA, 2019);

- Food Procurement Programme (PAA) to fight against hunger and poverty in Brazil and, at the same time, strengthen family farming through the government acquisition of products from family farmers, land reform settlements, indigenous and other traditional communities. The products are used for the formation of strategic stocks and distribution to the population in greater social vulnerability (MDA, 2019);

- National Programme of School Feeding (PNAE) offer school feeding and action of food and nutrition education to students from public education, monitored and supervised by society and several governmental institutions. At least 30% of the funding passed through PNAE should be invested to directly purchase products from family farmers to stimulate the economic and sustainable development of communities (FNDE, 2018). According to Sonnino et al. (2014, p.6) the school feeding was highlighted "as crucial tool to enhance citizens' access to food, to create markets for small and medium-sized suppliers and to improve children's food habitat".

- Zero Hunger Project was launched in 2003 as a Brazilian policy for food security and main governmental strategy to orient economic and social policies by the creation of an extraordinary Ministry of Food Security and Fight Against Hunger (FAO, 2010). The Project consists of a set of structural policies to reduce the food vulnerability of families by increasing income, universalizing social rights and access to food quality

and for reduction of income inequality. The project is structured in 4 axes: access to food, family farmers strengthening, income generation and social articulation, mobilization and control. Zero hunger achieved almost 25% of the Brazilian population, around 45 million people. The Millennium Development Goal to halve extreme poverty in Brazil was achieved ten years ahead of schedule. The family farmers' income increased 33% from 2003 to 2009 (FAO, 2010).

In order to describe the current status of food and nutrition security and the agri-food system in Brazil is essential to discuss the coup of 2016, which radically changed the Brazilian political orientation. After the fourth electoral victory of the left wing in Brazil (worker's party, PT) by 2014, a "coup coalition" (term defined by FPA, 2017) articulated a parliamentary juridical and media coup culminating in the illegal impeachment of the President Dilma Roussef in 2016 without any responsibility crime (see Villaverde, 2016, CNTE, 2017, Proner et al. 2016, Proner et al. 2016a, Souza, 2016, Braz, 2016, FPA, 2017, Bastos, 2017). According to Souza (2016) using the excuse of a biased anti-corruption discourse, the real aim of the coup was to halt the gradual social advances and reduction of inequality promoted by the worker's party and establish an ultra-neoliberal agenda instead. Villaverde (2016) describes 3 main big and powerful interests for the coup. Firstly, the reaction of the Brazilian elites to keep power and privileges threatened by the social rise of about 40 million Brazilians (18 million leaving the extreme poverty), the continuous increase of minimum wage, the high employment rates, and the increase of access of black and poor people to universities. Secondly, the interests of large international corporations and the most powerful countries in the world in the petroleum from pre-sal which would be explored by national corporations with national technology to subsidise national education, health and sovereignty, as well as consolidate Brazil as an emerging regional power. Thirdly the interests of national and international financial capital confronted by Dilma Roussef government who tried to eliminate the practice of rents with public debt as a systematic means of capital accumulation (also see Bastos, 2017). Finally other segments of the Brazilian elite joined the coup to avoid losing the secular domain exerted on the popular strata, i.e., the big media corporation, expressive portions of the judiciary and public prosecutor's office. Mattei (2018) describes some of the big setback in the agrarian policies made by the illegitimate new government after the coup:

- The extinction of the Ministry of Agrarian Development (MDA), converted into the Special Secretariat for Family Agriculture and Agrarian Development (SEAD) dismantling the institutional structure, especially technical teams responsible for the implementation and management of several policies;
- De-structuring the Food Acquisition Program (PAA);
- Cancelling of contracts at ATER that would benefit about a thousand family farmers association and cooperatives;
- The general de-structuring of technical teams;
- Changes in the conduct of agrarian policy, bringing more difficulties to promote land reform, facilitating national and foreign speculative capital, attending the demands of the ruralist lobby (BBB) of the National Congress which supported the coup;
- Large budget cuts were made in the sphere of agricultural policies and actions.

Lima et al. (2018) states that the agri-food agenda built in the worker's party governments was severely depleted and the stakeholders linked to family agriculture were removed from the process of foreign policy formulation. According to the authors this retrocession evidences the suppression of the project of insertion of Brazil as an emerging agrifood power in the centre of international relations. The conservative and regressive nature of the coup puts pressure on the public educational system for the purpose of destroying policies already instituted, to the detriment of the rights of rural populations historically discarded as peasants, indigenous and black (Orso, 2017, Santos, 2018, Ribeiro et al. 2018, Lastoria et al. 2018). Ribeiro Hora (2018) expresses her concerns with the continuation of approaches adopted in the processes of elaboration of public policies for the promotion of gender equality in rural areas due to extinction of the Rural Policy for Rural Women Directory (DPMR). Santana (2018) denounces the actions of the new government to weaken the fight against slave labour, mainly in rural areas to favour the coup supporters at the National Congress (BBB). Souza (2018) warns of the changes made in the legislation to ensure easy land transactions in the market, which lead to the re-concentration of land and make difficult the realization of Land Reform. Castilho (2018) points out that the ruralist lobby (BBB) had a decisive influence on the overthrow of an elected president and to maintain the coup in power. This action corresponded to an offensive against peasants, indigenous and quilombolas, criminalization of social movements and their defenders and territorial expansion. Friedrich et al. (2018) cites many other dismantling actions

coming from the influence of the BBB on the current government. They are the flexibilization of labour legislation, processes of environmental legislation, underfinancing of public policies for the production of organic and agroecological foods, lack of access to the health of rural populations and an increase in food and nutritional insecurity, as well as disrespect for food sovereignty. The report Violence against Indigenous peoples in Brazil launched in 2018 by the Indigenous Missionary Council (Cimi) seriously denounces that "the killers of the indigenous peoples are, more than ever, settled within the State" (Cimi, 2018, p.11). The conclusion of the report is that the State, led by the BBB act to annihilate with the constitutionally assured rights of indigenous people, quilombolas and other traditional communities consolidating a regime of violence and legal exception (Cimi, 2018).

The consolidation of the young Brazilian democracy faces a serious challenge. Social movements based on agroecology and food security and sovereignty are crucial pillars in this process. The wave of reflexive governance in Brazil strengthened the interactions between governmental institutions and civil society, creating new spaces and protagonism in both sectors for the conceptual discussion and actions about the sustainability of the Brazilian agri-food system. There is a strong movement embracing and spreading the concepts of food sovereignty and agroecology-based agricultural production in Latin America what Altieri & Toledo (2011) call "agroecological revolution". The authors state that agroecology provides the scientific, methodological and technological basis for this new agrarian revolution. Wezel et al. (2013, p.3) describe agroecological practices as "agricultural practices aiming to produce significant amounts of food, which valorise in the best way ecological processes and ecosystem services in integrating them as fundamental elements in the development of the practices, and not simply relying on ordinary techniques, such as chemical fertiliser and synthetic pesticide application or technological solutions, such as genetically modified organisms". Francis et al. (2003, p.114) define agroecology as "the study of the whole food system, embracing both natural and social sciences, and emphasizing systems thinking and ecological principles". Cabell et al. (2012) and Ríos-Osorio et al. (2013) attribute to the agroecosystem not only the physical space dedicated to production, but also the resources, climate, soil, infrastructure, markets, institutions, social structure, stakeholders, and the history of the system. "Agroecological methods produce more food on less land, using less energy, less water while enhancing the

natural resource base, providing ecological services and lowering outputs of greenhouse gases" (Altieri, 2012). Today agroecology could mean either a scientific discipline, agricultural practice, or political or social movement (Wezel et al. 2009). According to the authors although in Brazil all three interpretations can occur, there is a stronger emphasis of agroecology as movement and agricultural practice. Brazil is one of the countries where agroecology is gaining ground (Schutter, 2010). Altieri & Toledo (2011) point out that agroecological initiatives aim at transforming conventional agriculture towards an alternative agricultural paradigm, produced sustainably by local small and family farmers with access to means of production and markets. For Schutter (2010, p. 6) "agroecology is highly knowledge-intensive, based on techniques that are not delivered top-down but developed on the basis of farmers' knowledge and experimentation". Seminar et al. (2017) shows that this kind of knowledge can free farmers from being dependent on industrial agriculture and reduce farming costs. More than that, the practice of agroecology can empower farmers. Agroecology contributes to the right to food by raising productivity at field level (availability), reducing rural poverty (accessibility), improving nutrition (adequacy), adapting to climate change (sustainability) and being an asset for the dissemination of best practices (farmer participation) (De Schutter, 2010). Altieri & Toledo (2011) state that the agroecological revolution creates new forms of communication between activism and science. The Martinez-Alier & Rosset (2011) article corroborates with this argument mentioning the incorporation of agroecology in the vision of La Via Campesina, the most important transnational agrarian movement.

Latin America still has a huge variety of traditional and diverse agricultural systems adapted to different environments, culture and available resources. This complexity and diversity in farming systems are key to reduce vulnerability to climate disasters (Altieri & Toledo, 2011) and provides major impulse to the concepts of food sovereignty and agroecology (de Schutter, 2010). In Latin America the agroecology basis has been built in constant reciprocity with social movements and indigenous people and the emerging progressive governments (Altieri & Toledo, 2011). The Via Campesina is the result of the encounter between world different rural cultures (including indigenous movements) to face the neoliberal and dominant food regime using food sovereignty and agroecology as framework (Martinez-Torres & Rosset, 2014). The Via Campesina argues that the agroecological production by sustainable

small family farmers is the best suited model to meet future food needs and social justice, instead of the falling corporate food system (Via Campesina, 2010). La Via Campesina (2013) claims that food sovereignty and agroecology are crucial for the fight for social justice and sustainability. "During the last two decades our vision of food sovereignty has inspired a generation of activists engaged in social change. Our vision for our world encompasses an agricultural revolution as well as socio-economic and political transformation. Food sovereignty articulates the crucial importance of local and sustainable production, respect for human rights, fair food and agricultural prices, fair trade between countries, and the safeguarding of commons against privatization… …Agroecology defends biodiversity, cools down the planet and protects our soils. Our agricultural model not only can feed all of humanity but is also the way to stop the advance of the climate crisis through local production in harmony with our forests and waterways, enhancing diversity and returning organic matter to natural cycles." (La Via Campesina, 2013). La Via Campesina envisions agroecology as a social activating tool for the transformation of rural realities and key for the construction of food sovereignty (Martinez-Torres & Rosset, 2014).

Agroecology principles can bring not only food sovereignty for rural communities but also energy and technological sovereignty (Altieri & Toledo, 2011). According to the authors Brazil is the country with a more dramatic expansion of agroecology in the world, which started with the publication of Lutzenberger (1981), the 'Ecological fundamentals of agriculture' and Primavesi (1984), 'Ecological management of soils'. The Brazilian NGO AS-PTA (Advisory and Services to Projects in Alternative Agriculture) was the pioneer for the dissemination of agroecological information to other NGOs, farmer's organizations and students. Altieri & Toledo (2011) highlights three main process responsible for the advance of agroecology in Brazil: the training of a new educational professional that became professors and researchers in public universities, the adoption of agroecology by the movement of family agriculture and the hundreds of agroecological development initiatives made by the arrival of agroecologists to key state and federal government. The previous Ministry of Agrarian Development (MDA) played a major role to boost agroecology supporting education for family farmers and creating instruments for the access of family farmers to know how, credit and markets. Other important institutions were the Brazilian Association of Agroecology (ABA) and National Articulation of Agroecology. However, the most

significant reason for the rise of agroecology in Brazil is the ideological engagement of the main rural political organization of Brazil such as National Confederation of Workers in Agriculture (CONTAG), Federation of Workers in Family Agriculture (FETRAF) and Landless Rural Workers' Movement (MST) (Altieri & Toledo, 2011). The most important one, the MST, was created in 1984 and it is considered one of the most organized, dynamic and influential social movements in Latin America and one of the largest peasant movement in the world (Karriem, 2009). In its pathway, it has changed the discourse from a strong productivist point of view to an agroecologist one (Borsatto & Carmo, 2013). According to the authors a flexible and democratic cooperativism is still a strong axis of MST, however it also takes into account local specificities based on agroecology which began to gain importance in the movement since the 1990s. The change of orientation came from difficulties to carry on with the MST's previous productivist model and because of its growing interaction with La Via Campesina who had already environmental concerns (Picolotto & Piccin, 2008). Traditional peasant knowledge and environmental issues are central for MST. As expressed in its Proposal for Popular Land Reform, all the demands and efforts of the MST go towards the promotion of agroecology and food sovereignty (Azevedo, 2016). 'The Popular Land Reform guides the construction of a new agricultural model for the Brazilian countryside, going beyond a process of democratization of the land and proposing as strategy the establishment of an agricultural system as opposed to agribusiness. And it proposes as an alternative a model of production based on a agroecological matrix, for the production of healthy foods and respect for biodiversity, without the use of pesticides, aiming at agroindustrialization of the field and the development of the country… … to improve the living conditions of peasants and ensure the country's food sovereignty.' (MST, 2017, authors' translation). The Popular Land Reform is a MST's strategy to face agribusiness, conquer land for settlements, keep it and gain ground (Azevedo, 2016). MST is a vibrant counter-hegemonic actor in Brazilian politics territorialized in a national movement (Karriem, 2009). It has a deep 'political pedagogical project' (PPP) in the schools created in its settlements. The schools aim to educate students to be active participants in the development of regional agroecological science and critically reflect upon the relationships between political economic processes, power and landscape change (Meek, 2015). The author mentions that the MST's schools are important examples of how a school can critically educate

students and offer to them the possibility to develop methodological and theoretical tools to transform their reality based on social and environmental justice concerns. MST also has an active agenda in protection of human rights (MST, 2017) and national political mobilization (MST, 2017), for example against the coup and its consequences for the country. Although some internal struggle and failing to embrace livelihood diversification / pluriactivity (Chase, 2010), MST has achieved important common victories, such as land occupation and redistribution, and forced land issue into the political and legal debates (Caldeira, 2008). According to Wolford (2016) MST are "generating new collective understandings of what organization can do and how one can or should define social justice and good citizenship".

3

Methodological framework

3.1. Research approach

This thesis employs a mixed methods research, because as mentioned by Cresswell (2014), it incorporates elements of both qualitative and quantitative approaches. According to the author, a study tends to be more qualitative than quantitative or vice versa. This study is predominantly framed in a qualitative research because its analysis privileges words (qualitative) instead of numbers (quantitative) and open-ended questions (qualitative) rather than closed-ended questions (quantitative) (Cresswell, 2014). The reason for using mixed methods approach is that the combination of quantitative and qualitative approaches provides condition for a more complete understanding of the research problem within a pragmatic philosophical worldview (or paradigm). Pragmatists concern with applications and solutions to problem (Patton, 1990) and use pluralistic approaches to understand the problem (Patton, 1990, Morgan, 2007, Tashakkori & Teddlie, 2010). Pragmatism is a philosophical underpinning for mixed methods studies (Cresswell, 2014). Although this research seeks to find ways to improve and change its object (agri-food system), it does not come from a transformative worldview because it is centred in the whole system and not in a specific minority or marginalized group (Cresswell, 2014, Mertens, 2010). In addition, the participation of stakeholders is given more in a consultative frame rather than in a collaborative one, where participants may help design questions, collect data, analyse information, as seen in transformative paradigm. This research also is not centred in the quantitative determinism or reductionism from the postpositivism perspective. Neither it is structured in the pure qualitative inductiveness of the constructivism perspective which relies as much as possible on the participants' views of the object (Cresswell, 2014). In contrast with these perspectives, based on a pragmatic worldview and using mixed methods approaches, the ultimate aim of this research is to formulate and discuss transition pathways for a sustainable Brazilian agri-food system (chapter 6). In order to address this aim and the research gaps identified in the literature, I use

a participatory backcasting framework supported by content analysis, dividing the methodology into 3 main steps (figure 1): problem orientation (both quantitative and qualitative research, chapters 1 and 4), generating future vision (qualitative research, chapter 5) and backcasting analysis (qualitative research, chapter 6).
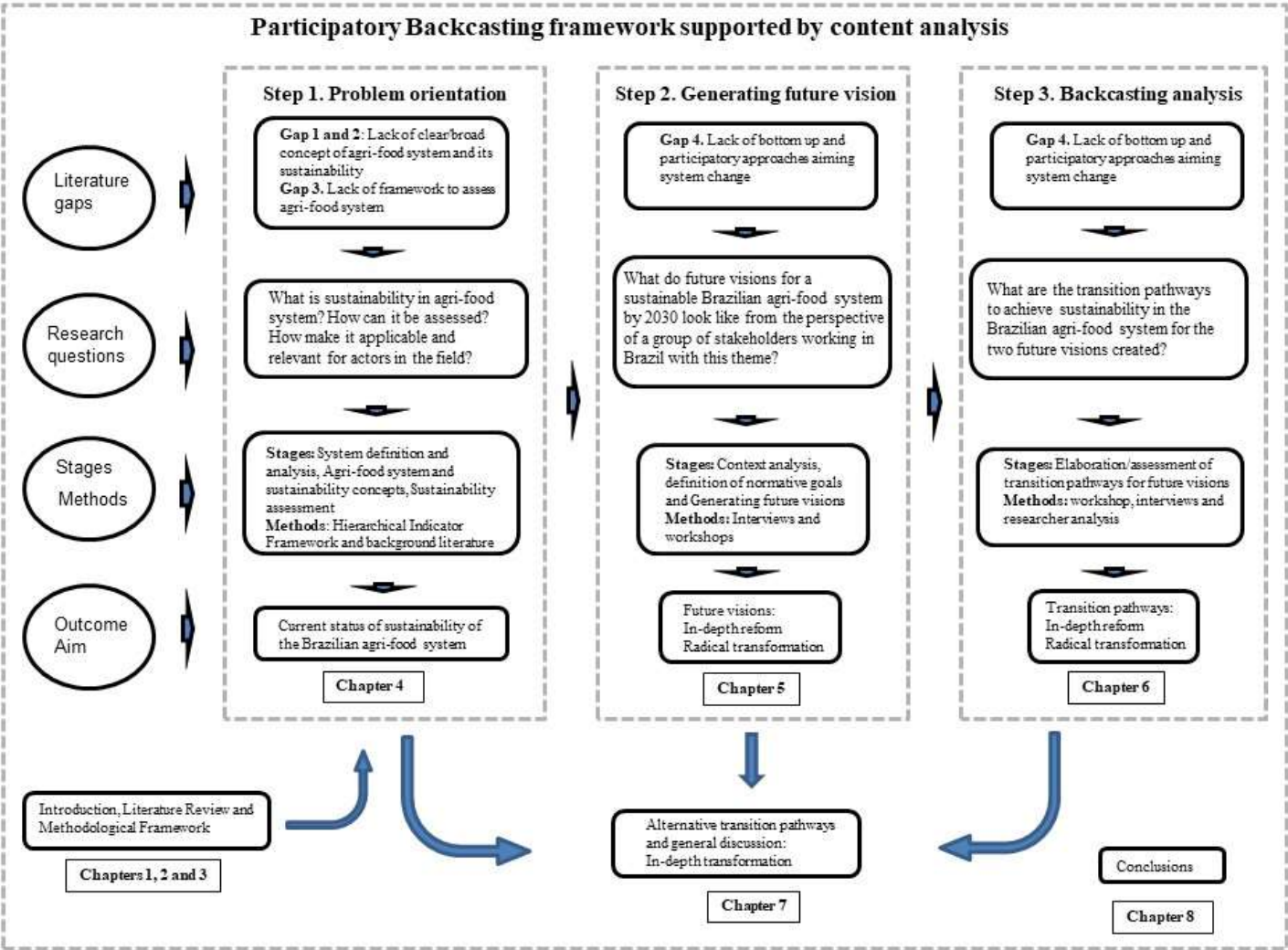
Figure 1. Methodological framework of the thesis

3.1.1. Participatory research

"Conventional research tends to package intervention methods and programmes into one-size fits- all, off-the-shelf approaches, based on a notion of universal best practices" (Lilja & Bellon, 2010, p.479). In contrast, participatory methods incorporate end-users views in the research process, addressing the drawbacks inherent to the approach chosen. According to the authors, this practice fosters trust in agriculture research by addressing important subjects to the communities, increasing research participation and helping to disseminate research into practice. It enhances capacities important for beneficiaries' learning (Lilja & Bellon, 2010). "Participatory research is a systematic inquiry, with the collaboration of those affected by the issue being studied, for the purposes of education and of taking action or affecting change" (Cargo & Mercer, 2008, p. 328). According to the authors, participatory research is the antithesis of the 'elitist research', which privileges the perspectives of the professional researcher, marginalizing the perspectives of participants. One of the origins of participatory research comes from the philosophies of Paulo Freire and his propositions about education as a liberation force in Brazil (Weller & Malheiros da Silva, 2011) through the 'conscientizacao' (critical consciousness) among oppressed peoples (Freire, 1970). Following Freirean pedagogies, the emancipation of oppressed people can only occur through their collective effort to stablish a dialogue (Higginbottom & Liamputtong, 2017). According to the authors, the dialogue referred by Freire is exactly what participatory research is about, i. e., more than talk and discussion, it also includes collective action and reflection. New knowledge and insights comes from the skills of the participatory research to integrate academic and theoretical perspectives with lived experience of participants (Cargo & Mercer, 2008). According to Kemmis et al. (2014, p. 5) there are five things only participatory research can do. It creates the conditions for practitioners to:

"1. Understand and develop the ways in which practices are conducted 'from within' the practice traditions that inform and orient them;

2. Speak a shared language, using the interpretive categories, and joining the conversations and critical debates of those whose action constitutes the practice being investigated;

3. Participate in and develop the forms of action and interaction in which the practice is conducted;

4. Participate in and develop the communities of practice through which the practice is conducted;

5. Individually and collectively, to transform the conduct and consequences of their practice to meet the needs of changing times and circumstances of irrational, unsustainable and/or unjust practices."

The participatory research is central for a deep understanding of the complexity of the object of this research (the agri-food system) as recommended by Lilja & Bellon, (2010), Cargo & Mercer (2008) and Kemmis et al. (2014). It is also crucial for the ability to bring to the light alternatives and insights to improve it and build transition pathways for its sustainability as mentioned by Kemmis et al. (2014). The participatory backcasting framework with the support of content analysis is a powerful mixed methods tool forged to accomplish with this aims. The backcasting approach naturally requires a participatory research (Quist and Vergragt 2006; Miola, 2008, Quist 2011).

3.2. Backcasting approach

Börjeson et al. (2006) distinguish scenario studies in three main categories according to the principal question about the future: What will happen? What can happen? and How can a specific target be reached? Predictive scenarios (e.g., forecasting scenario) respond to the first question, making an attempt to predict what is going to happen in the future, in order to plan or adapt to situations expected to occur. Explorative scenarios (e.g., strategic scenario) answer the second question, exploring situations or developments that could possibly happen, usually building a set of scenarios to expand the scope of possible developments. Normative scenarios (e.g. backcasting scenarios) respond to the third question, having an explicit normative goal to reach certain future situations or objectives and draw up how these could be realized. Rather than predict or explore alternative futures, the backcasting approaches are "visionary modes of thinking" (Börjeson et al., 2006: 724), delivering the task of drawing up transition

pathways for a sustainable agri-food system, in the case of this research. Sustainability transition are goal-oriented (Geels, 2011). According to Quist (2016), sustainability is a normative concept about long-term goals and changes. The author recommends the use of backcasting for sustainability studies because this methodology also has a normative nature. Vergragt and Quist (2011: 747), define backcasting as "generating a desirable future, and then looking backwards from that future to the present in order to strategize and to plan how it could be achieved". The backcasting approach tends to be a normative, long term oriented, system oriented, take a broad view on sustainability and are often participatory (Quist, 2013). The direct participation of the eventual users of the analysis is fruitful for the policy design and implementation issues that go beyond the questions of technical and economic feasibility (Robinson, 1990). Moreover, the backcasting is a participatory approach that has to involve several and heterogeneous stakeholders (Miola, 2008). The participation of experts and relevant stakeholders is essential to grasp and deal with the complexity of such processes towards a desirable and sustainable future (Wehrmeyer et al. 2013) and increase legitimacy and accountability of the process (Quist, 2011). Such sustainable innovation must be analysed from a systemic perspective, and implies a mutual learning and collaboration by the stakeholders related to the system (Voorn et al. 2012, Quist &. Tukker, 2013). Stakeholder participation in instruments like backcasting analysis, is a key factor to develop sustainable solutions (Maas, 2014). According to the author, the German government, for example, recognises the importance and incentivises the participatory development of sustainable strategies to reducing CO2 emissions on a city scale. Similar importance has been given to participatory backcasting in areas such as energy, building, health care, food, mobility and water management in the Netherlands, Canada, UK, Sweden and Belgium (Quist et al 2013b). The participatory backcasting "is an adequate approach to envisaging and exploring system innovations and transitions towards sustainability, and can be seen as a promising sustainable alternative to traditional planning" (Quist et al. 2011). The process also may contribute with guidance and orientation to a reflexive governance (Quist et al. 2010), an essential step to create rooted forms of sustainability into the agri-food systems (Feindt, 2010, Sonnino et al. 2016). Within the scope of the framework adapted from (Quist, 2013; Quist et al., 2013) and (Quist, 2016), I use and

link mixed methods to draw up transition pathways for a sustainable Brazilian agri-food system as seen in figure 1 and explained below

3. 2. 1. Chapter 4: Strategic problem orientation (step 1)

To generate a "desirable future" (referred to as future vision in this thesis) it is necessary to develop a deep understanding of the system. The starting point to generate a desirable future vision is hence to understand the context of the Brazilian agri-food system through a strategic problem orientation step, identifying sustainability issues and problems (Quist, 2016). The methodology applied in this first step of the participatory backcasting framework is the problem orientation (see figure 1). This first step is also a by-product of the thesis; because it answers in itself, very pertinent questions and gaps in the literature (see chapter 2 and step 1 of figure 1). The literature review of chapter 2 is also part of step 1. This information is essential for the understanding of the global and national context and for the interpretation of stakeholder opinions in the next steps. In addition to the context analysis from the literature review, I develop an indicator framework to deepen the understanding of the sustainability of the Brazilian agri-food system (chapter 4). It takes four stages to assess the sustainability of the Brazilian agri-food system: describing the agri-food system and the concept of sustainability (3.2.1.1), defining how the sustainability concept applies to the agri-food system (3.2.1.2) proposing a mechanism to identify the main challenges and link indicators of sustainability of the agri-food system to policy and goals (3.2.1.3) and analysis (3.2.1.4).

3. 2. 1. 1. Agri-food Systems: beyond food production and consumption

I provide a conceptual model of agri-food systems in figure 2, adapted from Ericksen (2008). The concept is compatible with the Millennium Development Goals (MDGs) methodology (UN, 2017, 2017a), Aichi Biodiversity Targets (UN, 2014), Sustainable Development Goals (SDGs) (UN, 2015) and adopted by the International Assessment of the Agricultural Knowledge, Science, Technology and Development of UNEP (IAASTD, 2009). According to this perspective, agri-food systems are defined as all

interactions involving the activities from production through to consumption of food, from field to table, including fibre and biofuels; the stakeholders involved, and the outcomes of these activities that influence the status of human wellbeing, food security/food sovereignty and environmental quality (adapted from Heller and Keoleian, 2003; Ericksen, 2008; IAASTD, 2009).
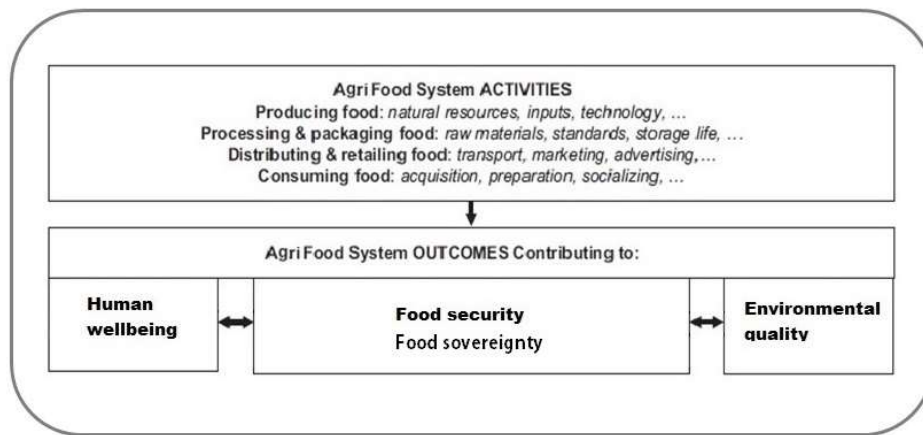
Figure 2. Agri-food system conceptual model adapted from Ericksen (2008)

Food is an ecosystem service as defined by the Millennium Assessment (2005, 2005a), Ericksen (2008), IAASTD (2009), MDG (National report published by IPEA, 2014) and Aichi targets (National report published by IUCN, 2011). It means that the interdependence and interconnectivity of its three outcomes are essential to consider an agri-food system healthy and sustainable. Consequently, the analysis of quality of its three outcomes is a very powerful mechanism to describe and understand a specific agri-food system. Based on these premises, the sustainability of an agri-food system is assessed here according to the well-functioning / quality of each element of these outcomes, defined as:

Human wellbeing has multiple components, including basic material for a good life, freedom of choice and action, health, good social relations, and security. Wellbeing is at the opposite end of a continuum from poverty, which has been defined as a pronounced deprivation in wellbeing. The constituents of wellbeing, as experienced and perceived by people, depend on specific situations, reflect local territories, culture, and ecological contexts (Millennium Assessment, 2005a: v).

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Food security "exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996: paragraph 1).

Food sovereignty "is the right of peoples to define their own food and agriculture; to protect and regulate domestic agricultural production and trade in order to achieve sustainable development objectives; to determine the extent to which they want to be self-reliant; to restrict the dumping of products in their markets, and; to provide local fisheries-based communities the priority in managing the use of and the rights to aquatic resources. Food sovereignty does not negate trade, but rather, it promotes the formulation of trade policies and practices that serve the rights of peoples to safe, healthy and ecologically sustainable production." (Peoples' Food Sovereignty Statement, 2017: 1).

Environmental quality: In order to be multi-functional and multidimensional, an agri-food system has to guarantee ecosystem functionality. "Ecosystem Function is an intrinsic ecosystem characteristic related to the set of conditions and processes whereby an ecosystem maintains its integrity (such as primary productivity, food chain, biogeochemical cycles). Ecosystem functions include such processes as decomposition, production, pollination, predation, parasitism, nutrient cycling, and fluxes of nutrients and energy" (IAASTD, 2009: 562).

This concept of agri-food system is chosen because it incorporates the two central points for sustainability advocated in this research. First, it embraces the multi-functionality and multidimensionality aspects (see literature review in chapter 2), both essential elements for the sustainability of the agri-food system. Finally, it is policy relevant, once it is recognized and incorporated into the UN policies and agreements such as MDGs, Aichi targets, MA, IAASTD, FAO and consequently into national and local policies.

3. 2. 1. 2. Hierarchical Indicator Framework

To define and assess the well-functioning of an agri-food system, I propose the establishment of a logical framework connecting principles and criteria to indicators. The well-functioning of criteria explains the status of sustainability of the system by

the assessment of their set of indicators. Some indicators could be part of more than one criterion; however, I link them to only one criterion. The theoretical framework to evaluate agri-food sustainability through a set of indicators was adapted from Gomez-Limon (2012). Figure 3 illustrates the framework, which follows a hierarchical structure to evaluate agri-food system sustainability assessing the quality of the outcomes of the agri-food system (described in figure 2). Hence, the status of the outcomes of the agri-food system are the principles of sustainability. **Principles** of sustainability will be achieved only when the environmental quality, food security/sovereignty and human wellbeing of an agri-food system is guaranteed. In other words, principles are presented here as essential conditions for achieving sustainability, taking into account the multiple functions (multi-functionality) of agri-food systems and consequently including the multidimensionality of sustainability: social, economic and environmental. **Criteria** express the resulting state of agri-food systems when their related principles are respected in a specific theme. The selection of themes is flexible and should reflect the aim of research, analysis, scale, governance etc. Criteria are composed by a set of indicators that characterize problems, challenges and strengths of its specific theme. **An indicator** is a final variable that is assessed in order to measure compliance with a criterion and subsequently to produce a representative picture of the sustainability of the specific theme. Figure 4 shows the hierarchical framework proposed to discuss the sustainability of the Brazilian agri-food system. Five different criteria themes are categorized: 1. Equity and social welfare (general, rural/urban, gender); 2. Economic stability & investment in infrastructure, research and technology; 3. Culture & tradition preservation; 4. Ecosystem service provision & biodiversity conservation; 5. Use of natural resources & pollution.
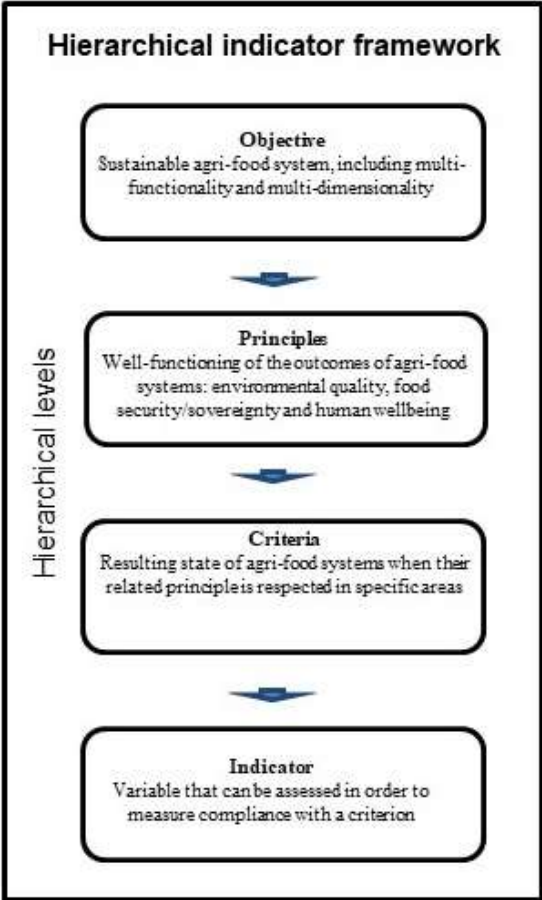
Figure 3. Hierarchical indicator framework to assess sustainability of agri-food systems adapted from Gomez-Limon (2012)
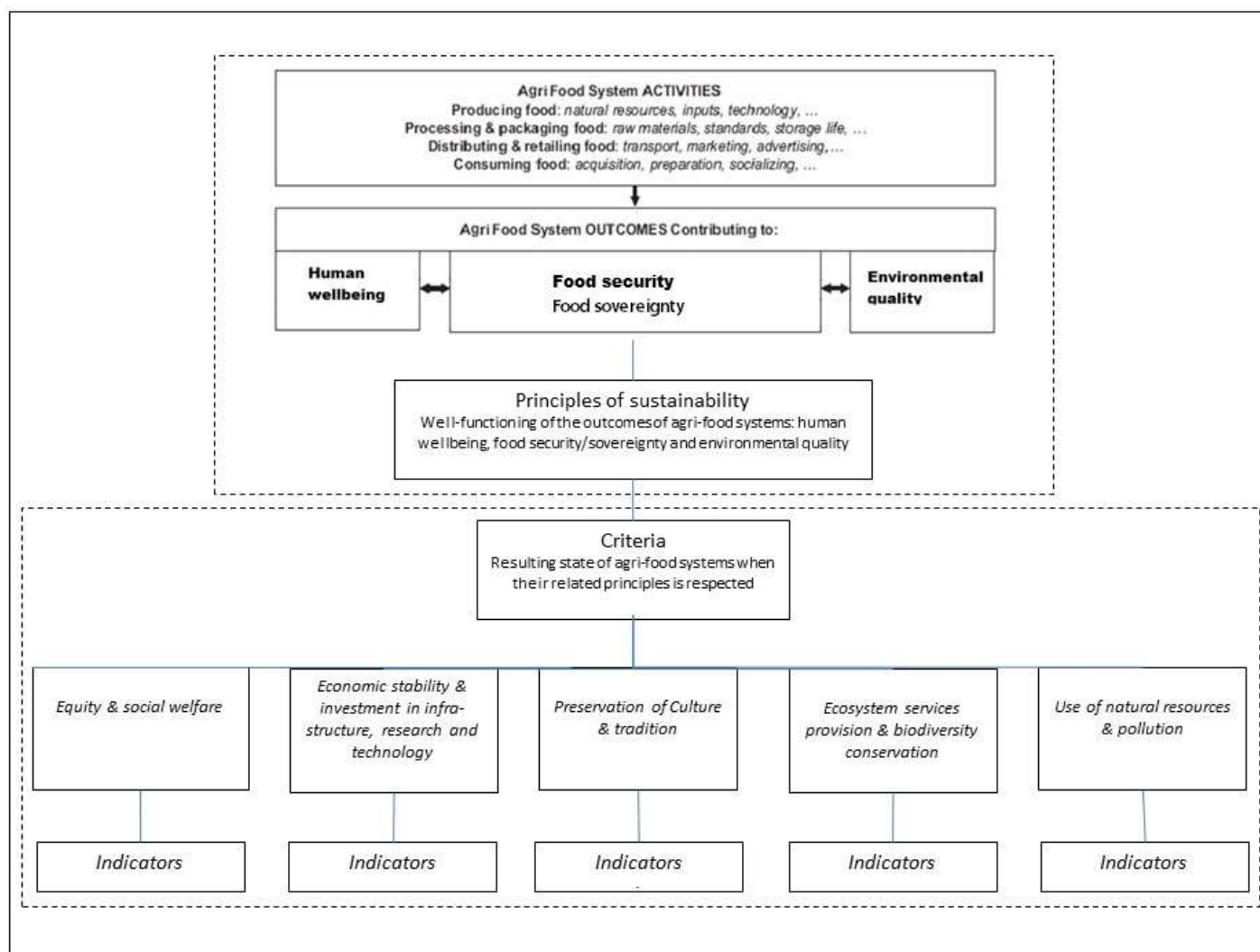
Figure 4. Detailed hierarchical indicator framework to assess sustainability of the Brazilian agri-food systems

3. 2. 1. 3. Policy relevance

I select a set of 51 indicators of sustainability, and sort them into five groups of criteria, based on the literature review, MDGs and Aichi targets plus suggestions from this research. I present them briefly in table 8, chapter 4 and with more detail in appendix 1. Each indicator relates to a principle, a criterion, source, unit, the author that recommended it, policy relevance, target/limits. If the indicator is included in MDGs and/or Aichi targets, the specific target and level of compliance are also given. For the MDGs the deadline to accomplish the goals was 2015, and for the Aichi targets it is 2020. For new assessments, I recommend the use of the SDGs as one of the policy instruments of analysis. For this research, it was more feasible to test the hierarchical indicator framework using the results of the MDGs targets in order to have an overview of the status of the agri-food system's sustainability.

3. 2. 1. 4. Analysis

Sustainability is not a static objective to be achieved, but something dynamic that needs constant efforts of maintenance and/or improvements as the world is continuously changing. In this context, I organize and discuss the indicators in terms of their performance of sustainability by criteria. I use five criteria to discuss the sustainability of the Brazilian agri-food system: Equity & social welfare, Economic stability & investment in infrastructure, Research and technology, Preservation of Culture & tradition, Ecosystem service provision & biodiversity conservation and Use of natural resources & pollution. The majority of indicators identified in the literature review (see Corbiere-Nicollier et al., 2011; Dantsis et al., 2010; Gabrielle, 2014; Verburg, 2014, for example) to represent sustainability in agri-food systems are represented or are to some extent related to the indicators selected by the MDGs (IPEA, 2014) and Aichi Targets (IUCN, 2011) to measure the achievement of goals and targets of sustainability from these international agreements. Therefore, the contribution to sustainability is determined by the level of compliance/fulfilment of the indicator regarding to MDG, Aichi targets and/or by literature recommendations. Compliance is defined by analysis of the achievements of the targets/limits proposed for each indicator. I define three levels of compliance: high improvement (when it achieves the level recommended as ideal by MDGs or Aichi target), some

improvement (when it achieves a considerable improvement or complies with a partial target) or no improvement (when there is no or very low improvement) (table 8, chapter 4).

The aim of this approach is to identify which aspects of sustainability are better or worse and where an improvement or maintenance of quality is needed. The intention is to generate an applicable and policy relevant mechanism to assess the status of sustainability of the Brazilian agri-food system, based on broad and well-established concepts. The objective is to create the evidence base of data to produce narratives of the status of sustainability per criterion (problem orientation step, figure 1). The narratives in turn, feed and support discussion and choice of different sustainable pathways for the agri-food system (steps future vision and backcasting analysis, figure 1).

3. 2. 2. Chapter 5: Generating future vision (step 2)

I generate a future vision for a sustainable Brazilian agri-food system, adapting the participatory backcasting framework (step 2, figure 1) proposed by Quist & Tukker (2013) and Quist (2015). According to Quist et al. (2013: 46), the vision "is based on the consolidated problem perception…as well as the guiding sustainability principles". Three stages were adopted to achieve this aim: context analysis, definition of normative goals and generating future visions. Chapters 2, 3 and 4 address the first two stages and are pre-requisites of the third. The first stage is to understand the context of the Brazilian agri-food system, raising principal aspects of current unsustainability, barriers and opportunities for solutions, national policies and trends. This information comes from an analysis of the literature review (chapter 2) and results found in chapter 4 about the sustainability of the Brazilian agri-food system. The **context analysis** (stage 1), also named as strategic problem orientation, gives the basis for the definition of the **normative goal** (stage 2), which is the goal (s) that the future vision has to achieve in order to be considered sustainable. In this research, the normative goal is the establishment of a sustainable Brazilian agri-food system, following the concept of sustainability defined in chapter 4. In others words, the goal of the future vision created in this chapter, is to achieve the well-functioning of the three principles of sustainability of the Brazilian agri-food system: human wellbeing, food security/sovereignty and environmental quality. The third stage of step 2 (figure

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1), also named generating future vision uses one workshop and 26 interviews (see section participatory approaches in this chapter) with stakeholders to produce two future visions (In-depth reform and Radical transformation). I use content analysis (see description below) to identify and build narratives of the two future visions. Two complementary approaches were used: a workshop and interviews with stakeholders working in this area in Brazil. The generating future vision stage is divided into two phases: the first one explains the data collection and data analysis from the workshop and interviews and the second produces the meta-text describing two future visions, according to the methodology explained below.

3. 2. 2. 1. Stakeholders selection

Following the definition of agri-food systems adopted by this research, I consider stakeholders of the sector to be someone professionally involved with the production or consumption of food, fibre, biofuel as well as activities related to trade or improvement of the access and quality of the agri-food system, or reduction of the negative impacts of these activities. People selected by this research are farmers (or farmer's associations), researchers, industry/investors, government, NGOs, certifiers/consultants based in or close to the city of Brasilia or São Paulo, Brazil. I conducted 26 interviews and 2 workshops to obtain information and insights from stakeholders to produce the future visions (chapter 5) and to build the transition pathways for a sustainable Brazilian agri-food system (chapter 6 and 7). The participatory process improves the legitimacy of the research and provides a virtuous mechanism to promote engagement and to deliver policy relevant and applicable results (Quist, 2011). In the sequence, I describe the method used in the interviews and in the future visions workshop and the method used in the transition pathways workshop. table 1 shows the number of participants per event.

Table 1. Stakeholders that attended the workshops and interviews

	Interviews (A)	Future visions workshop (B)	Transition pathways workshop (C)	Participate in A and B	Participate in A, B and C
Researcher	3	4	2	2	1
NGO	8	4	0	2	0
Government	7	4	3	4	0
Industry/Investors	3	3	2	2	2
Consultant	2	0	0	0	0
Farmer	3	1	1	1	1
Total	26	16	8	11	4

3. 2. 2. 2. Content analysis

As previously stated, the creation of a future vision is essential in a participatory backcasting approach (Quist, 2013). Usually, these participatory approaches use workshops and interviews with stakeholders to build the future vision. Brainstorming of ideas is a common method applied for the construction of the vision of backcasting studies (Börjeson et al., 2006). I use the content analysis methodology in order to provide clarity and reproducibility to the participatory backcasting approach. According to Neuendorf (2002, p. 10) content analysis is a "summarizing, quantitative analysis of messages that relies on the scientific method… …and is not limited as to the types of variables that may be measured on the context in which the messages are created or presented". Krippendorf (2004, p. 18) defines content analysis as a "research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use". The content analyst can "provide aggregate accounts of inferences from large bodies of data that reveals trends, patterns, and differences no longer obvious to the untrained individual" (Krippendorf, 1989, p. 404). Content analysis can include quantitative and qualitative research. Quantitative analysis presents the results in form of frequency, usually answering the question of how many. Qualitative analysis presents data in the form of categories, corroborating with an important tool for this research, i. e., enabling interpretation of the text (Bengtsson, 2016). The inductive category development instead of imposing a preconceived theoretical perspectives on the data (Moldavska, 2017), "develop the aspects of interpretation, the categories, as near as possible to the material, to formulate them in terms of the material" (Mayring, 2000, p. 2). The deductive approach (or

directed content analysis) "is based on previously formulated, theoretically derived categories and the initial coding starts with a theory or relevant research findings" (Moretti, 2011, p. 421). I use the qualitative deductive (or directed) content analysis adapting the methodology described by Elo & Kyngas, 2008, Moldavska, 2017 and Bengtsson, 2016. A content analysis also requires a decision between latent and manifest content analysis. The manifest content analysis describes, "what the informants actually say, stays very close to the text, uses the words themselves, and describes the visible and obvious in the text" (Bengtsson, 2016, p. 10). On the other hand, the latent analysis explores what the informants intended to say in a deep interpretative structure. I perform the manifest content analysis because a broad surface structure fits the scientific question better. There is a lack of a common recipe, execution standard (Moldavska, 2017) or systematic rules for analysing data (Elo & Kyngas, 2008) for the content analysis. I follow the steps approached by Elo & Kyngas, 2008, Bengtsson, 2016 and Moldavska, 2017: the preparation phase, the organising phase and reporting phase. The methodology provides guidance to the process of defining interpretative units, categorizing them and finally converting the categorized units into narratives that generated the two future visions (In-depth reform and Radical transformation). The main feature of all content analysis is that the entire original text is classified into smaller content categories (Burnard, 1995) seeking some understanding of it (Bengtsson, 2016). In this process, the researcher tries to remain loyal to the text and to achieve trustworthiness (Downe-Wambolt, 1992).

Deductive Content Analysis

A. Preparation phase

According to Elo et al. (2014) the preparation phase is a collection of the suitable data and making sense of the data. The start point of the preparation phase is the selection of the units of analysis (Canavagh, 1997). The concept of unit of analysis is related to the sample, where the researcher has to decide the size and how to divide the original text into smaller units (Bengtsson, 2016). "The most suitable unit of analysis is whole interviews or observational protocols that are large enough to be considered a whole and small enough to be possible to keep in mind as a context for the meaning unit,

during the analysis process" (Graneheim & Lundman, 2004, p. 106). Bengtsson (2016) calls the preparation phase as planning phase with definition of aim, sample and unit of analysis, method of data collection and method of analysis. For this research, the **aim** of the content analysis is to generate visions of sustainability for the Brazilian agri-food system as a supportive tool for the backcasting approach. The **sample and unit of analysis** are the feedback collected from stakeholders with experience in the field. The **method of data collection** are workshops and interviews and the **method of analysis** are questions answered by brainstorming through the workshops and questions answered during the interviews. In many cases, the questions from the interviews are similar to the questions of the workshops.

Future visions workshop

On September 2nd 2015 at the University of Brasilia in Brasilia, Brazil, I ran a workshop with Brazilian stakeholders aiming to create a future vision for the sustainability of the Brazilian agri-food system by 2030 (table 2). In total, 16 stakeholders attended the workshop: four researchers, four NGOs/social movement representatives, four government representatives, three industry/investor representative and one farmer (see definitions and details in the section 3. 2. 2. 1.).

I adapt the workshop approach from the backcasting framework performed by (Quist, 2013) and (Quist, 2016). Based on the results of the previous chapters two and four, at the start of the workshop I presented the **context analysis** (stage 1) of the Brazilian agri-food system and the structure and aims of the research. The following issues were discussed:

- Why to study food
- Agri-food system concept
- Structure and aims of the research
- The concept of sustainability in agri-food systems adopted by the research
- Scenario building methodology
- Current situation of the Brazilian agri-food system
- Aim, activities and tasks of the "future visions workshop"
- Next steps

During this presentation, I also explained the second stage of the generating future vision step, outlining to stakeholders the **normative goal** (stage 2) of the creation of future visions for a sustainable agri-food system, i.e. to achieve the well-functioning of the three principles of sustainability of the Brazilian agri-food system: human wellbeing, food security/sovereignty and environmental quality.

The third stage was to generate the future visions, **brainstorming and clustering stakeholder ideas** to achieve the normative sustainability goals of the Brazilian agri-food system. Table 2 describes the structure of the workshop. The stakeholders were divided into three groups to perform the brainstorming activity (2 groups of 5 and 1 group of 6 participants divided randomly). In a logical sequence of ideas, each group performed a brainstorm, highlighting:

- which elements (core idea) are necessary to occur for the accomplishment of the normative goals of sustainability for the Brazilian agri-food system;
- what changes (measures) are needed to bring them about (technological, cultural and behavioural and structural);
- how the changes can be brought about;
- who could contribute and who would oppose the required changes.

Only the first question was used to create future visions for the Brazilian agri-food system sustainability. The other ones were used to build transition pathways towards sustainability in chapter 6.

I trained two assistants to help me run the workshops. Each of us facilitated one group of stakeholders. Ideas generated from discussions and brainstorming in the groups were recorded on paper and stuck on the wall.

The final activity of the workshop was to present the ideas from each group to the whole group for discussion, followed by a general discussion about the results of the workshop and next steps of the research. The stakeholder's presentations and final discussions were audio recorded and transcribed. At the end of the discussion individual stakeholders chose the three most relevant and priority elements or measures. They were also asked to mark up to three elements or measures that they judged would be counterproductive or negative for the sustainability of the agri-food system.

Table 2. Structure of the future visions workshop

Future visions workshop 16 participants, 1 moderator, 2 assistants	Time (min.)
General presentation Welcome, goals and guidelines for the workshop, problem analysis presentation	20 min
Visioning session* 1. Work in groups: Brainstorming of sustainable future and actions for reaching it *Support questions* *How should the agri-food system be by 2030 to become sustainable? Which are the essential "elements" for the Brazilian agri-food system to be considered sustainable?* What changes are needed to bring about the vision of sustainability of the Brazilian agri-food system? (Technological changes, cultural and behavioural changes, structural changes)** How can the changes be brought about? (Overall strategy or mechanism)** Who could or should contribute to realizing the vision? ** Who would oppose the required changes? ** 2. General assembly to present and discuss the outcomes 3. Personal selection of the elements that should be addressed as priority	180
Next steps	5
Networking	Free

*There was no stop for coffee break. It was available from 3.30 pm onwards during the work in groups.

** These questions were used only on chapter 6 to describe the transition for a sustainable Brazilian agri-food system.

Stakeholder interviews

Between August and November 2015, I interviewed 26 stakeholders about the sustainability of the Brazilian agri-food system (see details in the section 3. 2. 2. 1., participatory approach section). I invited stakeholders to participate in the whole process of the research, i.e., workshops and interviews. Therefore, the selection and

invitation of stakeholders for the workshops and interviews followed the same definition and process. I interviewed 22 stakeholders face-to-face and four of them by Skype. Their current professional activities were: three researchers, eight from NGOs/social movement, seven from government, three from industry/investors, two consultants and three farmers. Eleven of the interviewed people also participated in the future visions workshop. The interviews were based on the semi-structured interviews from the Inter-American Institute for Cooperation on Agriculture method (Geilfus, 2002). Interviews lasted on average 70 – 75 minutes. I recorded all interviews using professional recording equipment and afterwards I transcribed them to a word document. The set of texts (transcriptions) is the result "corpus" (raw material for analysis).

Complementary to the workshop, information from the first seven out of seventeen questions of the interviewed provided inputs for the creation of the future visions for the sustainability of the Brazilian agri-food system. All questions from the interviews are in appendix 2. At the beginning of the interview (Part A – General questions), I gave a short presentation about the aims of the research, the concept of agri-food system and the concept of sustainability (human well-being, food security/sovereignty and environmental quality). To avoid biased views from stakeholders, I did not mention any problem or solution for the system, using appendices 3 and 4 to illustrate the presentation. Before starting the second part of the interview (Part B – Specific questions), I introduced my finding of problems and strengths of the Brazilian agri-food system and the goals and targets of the international agreements to achieve agri-food system sustainability. Similarly to the workshop, the presentation was a compilation and synthesis of the outcomes found in chapters 2 and 4.

B. Selecting the unit of analysis

As suggested by Alexander (2016), I read several times the entire compilation of the workshop and interviews highlighting important portions of raw text and quotes, and finally selecting a word or a short phrase to represent the meaning of a specific question or topic.

Future visions workshop

For the workshop, the stakeholders' brainstorming ideas recorded on the posters form the units of analysis (see table 10, chapter 5). The units of analysis from the workshop used in this chapter are only the "elements of sustainability" considered by stakeholders as essential to achieve sustainability in the Brazilian agri-food system (the first question of table 2). These "elements" were widely discussed by stakeholders during the workshop.

Interviews

For each interview (Researcher 1 – R1, ONG 1 – O1; Researcher 2 – R2, etc), I highlight parts of the transcribed text (words, sentences) that represented the units of analysis, i. e., core ideas representing the answer for each question/issue (A1. Problem, A2. Solution, A3a. Institutional sustainability goals, A3b. Personal goals, B1. Institutional compliance to sustainability, B2. International agreements, B3. National policy). Then, I include the core ideas from each stakeholder in the same Excel spreadsheet per question (A1, A2…)(table 3).

Table 3. Examples of units of analysis from the interviews

	A1. Problem	A2. Solution
R1	chemical use intensive production monoculture	Reinvention of the agri-food system Short term is more diagnostic Long term is more systemic, influencing policy and management
O1	chemical use misuse of the soil animal ethics lack of regulation lack of stimulus for a transition small consumption of sustainable products waste	Consumer charging and taking decisions based on the degree of sustainability, practice along the chain Linked public financing (principles and criteria of sustainability) to sustainability standards and emission reductions
R2	inadequate access to food education for consumption chemical use misuse of water resources	Country needs to better distribute the income Better education Better control of agribusiness especially agro-chemicals and use of natural resources Payments for environmental services

C. Organizing phase

As suggested by Elo & Kyngas (2008) about the deductive content analysis, I develop a categorization matrix (table 4) and code the data according to the categories (see table 10 for the Future visions workshop and table 11 for the interviews, chapter 5). Following the same authors, I create a new category (Governance category in table 10 and 11, chapter 5) including the elements that do not fit the previous categorization matrix.

Future vision workshop

Without making any changes, I group the "elements of sustainability" (generated by the stakeholders) following the 5 criteria of sustainability developed in chapter 4 (equity & social welfare, economic stability & investment, culture & tradition preservation, ecosystem services provision & biodiversity conservation, use of natural resources & pollution) plus the new one (governance). Based on contrasting ideas (two different trends) in the stakeholders' opinions, for each criteria I classify the "elements of sustainability" into three categories: future vision I, consensus or harmonious ideas and future vision II (table 10, chapter 5). The "elements of sustainability" classified as future vision I aligns with ideas of reform and regulation of the system, while the future vision II ones tend to advocate for a more equitable and radical transformation of the system. Table 4 shows an example of the criterion Equity & social welfare. Some

stakeholder claimed that a sustainable Brazilian agri-food system has to provide access to adequate and healthy food for the population. Other stakeholders' went beyond this view, considering that sustainability is only possible with redistribution of land and wealth. The intermediate category includes "elements of sustainability" that were consensual among stakeholders. The complete results are in the table 10, chapter 5.

Table 4. Example of clustering and classification of "elements of sustainability" from the Future visions workshop

Criteria	Future vision I	Consensus or harmonious ideas	Future vision II
Equity & social welfare	full social and productive inclusion in agriculture		redistribution of land and wealth
	access to adequate and healthy food		equity in distribution

Interviews

The categorization matrix (Elo & Kyngas, 2008) from the interviews (based on question A1 to B3, appendix 2) follows a similar process made on the categorization matrix from the Future visions workshop. Firstly, for each question, I group the core ideas from the stakeholders' answers (e. g. table 5) into the 5 criteria of sustainability developed in chapter 4 (equity & social welfare, economic stability & investment, culture & tradition preservation, ecosystem services provision & biodiversity conservation, use of natural resources & pollution). Secondly, as recommended by Alexander (2016), I re-read the whole interviews several times, as well as the new tables grouped by criteria (see examples on table 5), then I re-write and re-organize stakeholders' information into three new categories (table 11, chapter 5). The first category aligned with the idea of reform and regulation of the system (future vision I), the second with consensus and harmonious ideas among stakeholders and the third one with more equitable and radical transformation ideas (future vision II) (table 11, chapter 5). In the table 11, land reform, land distribution, income distribution, production connected to the local system are ideas related to a strong transformations of the agri-food system (Future vision I), while payment for ecosystem services, better

management practices of natural resources during the production and agrochemical control are ideas for a moderate reform of the agri-food system (Future vision II). However, the need of a higher quality education for the improvement of the agri-food system is a consensus idea among stakeholders and can incorporate to both visions.

Table 5. A few examples of stakeholders' opinion about solutions (question A2, appendix 2) for the sustainability of the Brazilian agri-food system organized by criteria

Equity and social welfare	ES & biodiversity conservation
Land reform, land distribution	Payment for ecosystem services
High quality education	Better management practices of natural resources during the production, agrochemical control
Income distribution	Production connected to the local system

D. Reporting the analysing process and the results

According to Bengtsson (2016) after stablishing the categories, the analysis and writing up process begin. I performed the manifest analysis (within deductive content analysis) using the informant's words, as suggested by Bengtsson (2016) and to stay closer to the original meanings and contexts (Burnard, 1991). For each question, I clustered the core ideas from stakeholder interviews that were closely related to each other in a same row and different columns. See the example of table 6 for the question A1 (appendix 2) grouping core ideas for the criterion equity & social welfare. From the analysis of this categorization matrix as suggested by Elo & Kyngas (2008) and from reading several times all answers for this question as susggested by Alexander (2016), I created a narrative. In this example, the narrative of social inequality (appendix 6, item A1.1) was built from the following clustered core ideas given by stakeholders: social deprivation; unequal access to the means of production; income, land and capital concentration; formation of slums in cities; system does not bring equal benefits to the whole of society, violence and murders; etc (table 6). Another

example of a cluster is the problem of the hegemony of commodification, exportation and low added value system (appendix 6, A1.8) for which the core ideas were: commodification, hegemony of a model for exportation with low added value to agricultural products, disparity between the benefits and allowances received by the family agriculture versus agribusiness, etc. For both examples of cluster, different stakeholders cited some of these core ideas several times.

Table 6. Core ideas for the criterion equity & social welfare

Equity and social welfare	social deprivation	unequal access to the means of production;	income, land and capital concentration;	formation of slums in cities	system does not bring equal benefits to the whole of society	unequal system;	poor human health	violence and murders;

Finally, I produced a general narrative (meta-text, as called by Moraes & Galiazzi 2011) to describe two stakeholders' future visions for the sustainability of the agri-food system. The future visions offer supporting ideas and evidence of variations in stakeholders' opinions. The narrative construction of the future visions followed the structure (criteria) developed for the hierarchical indicator framework (figure 4, chapter 3) to conceptualize and describe the sustainability of agri-food systems. The use of this framework in all chapters of this research gives a reference that permits an analysis and comparison of distinct viewpoints in relation to the specific perspective of sustainability adopted by this research (see chapter 4). The criteria group from the indicator framework was the main mechanism of comparison and analysis of the stakeholder's feedback. Following Moraes and Galiazzi (2011), I built the themes and their meanings based on previous theories and/or context, with the intention to understand and reconstruct existent knowledge about the subject studied.

3. 2. 3. Chapter 6: Backcasting analysis (step 3)

The generation of a future vision is crucial in a participatory backcasting approach (Quist, 2013). It is a prerequisite to guiding the formulation of strategies and measures to build transition pathways for the sustainability of the Brazilian agri-food system, the aim of the third step of the framework, the **backcasting analysis** . The transition pathways for the two future visions reproduces the insights of stakeholders based on interviews and two workshops (the Future visions workshop and transition pathways

workshop). A further assessment of the transition pathways also takes into account the results of the workshops, interviews, background literature (chapter 2), a sustainability assessment of the Brazilian agri-food system (chapter 4) and future vision (chapter 5). Adapting (Quist, 2013) and (Quist, 2016), the backcasting analysis includes the design of a transition pathway for both visions and viability for their implementation. The analysis builds a normative scenario for the visions, taking into account results from workshops, interviews and the literature review, and then examining the consistency between their aims and expected results. I follow the cited author's recommendation of producing policy analysis for both pathways in order to identify which policies and initiatives are required to implement the future vision and how to bring them to light. According to the approach of Quist (2013, p.761) backcasting analysis looks "backward from the desired future situation, evolving around the questions 'WHAT changes are needed to bring about the vision?', 'HOW can the changes be brought about?', and 'WHO could or should contribute or oppose realizing the vision and what activities should they do?" The data analysis starts with the 'what-how-who analysis' that gives inputs for the second stage, the development of transition pathways. The third stage, the scenario sustainability analysis, compares the transition pathways of both visions in terms of opportunities, barriers, who should contribute and who would oppose the implementation of sustainability. The scenario sustainability analysis also compares how visions address the problems and solutions given by stakeholders and how both visions relate to the results found with the hierarchical indicator framework in chapter 4. Also in the sustainability analysis, I present the contradictions and main challenges for the implementation of the visions. I elaborate the backcasting analysis with the support of the qualitative content analysis, to identify, interpret and analyse stakeholder' opinions. However, in order to capture innovative and creative measures, strategies and insights from stakeholders, at this time I use the inductive analysis instead of the deductive one, once it does not impose a preconceived theoretical perspective on the data (Moldavska, 2017). The qualitative inductive content analysis designed for this research allows themes to emerge fully from the stakeholders by workshops and interviews (Alexander, 2016), and the categories derives from the original data (Elo & Kyngas, 2008). I use the qualitative inductive content analysis adapting the methodology described by Elo & Kyngas, 2008, Alexander, 2016, Moldavska, 2017 and Bengtsson, 2016. The focus of the analysis is on manifest

analysis, because I describe, "what the informants actually say, stay very close to the text, use the words themselves, and describe the visible and obvious in the text" (Bengtsson, 2016, p. 10).

Inductive Content Analysis

A. Preparation phase

The preparation phase process is similar for the inductive and deductive content analysis (Elo & Kyngas, 2008). Then, similar to the previous preparation phase of content analysis in this chapter, following Bengtsson (2016), the **sample and unit of analysis** are the feedback collected from stakeholders (see section 3.2.2.1). The **method of data collection** are workshops and interviews and the **method of analysis** are questions answered by brainstorming through the workshops and questions answered during the interviews.

Future visions workshop

I use all the information collected in the Future visions workshop with the exception of the first two questions (see table 2 in this chapter) to build the transition pathways. The workshop methodology is described in the preparation phase of the deductive content analysis to build the future visions for the Brazilian agri-food system in this chapter (section 3.2.2.2).

Interviews

I use all the information collected from the interviews to build the transition pathways. The methodology of the interviews is also described in the preparation phase of the deductive content analysis in this chapter (section 3.2.2.2).

Chapter 3

Transition pathways workshop

On 17th November 2015 at the University of Brasilia in Brasilia, Brazil, I ran the transition pathways workshop with two aims. The first aim was to receive feedback from stakeholders about the preliminary results of the transition pathways for the sustainability of the Brazilian agri-food system by 2030, based on preliminary outcomes from the future visions workshop and interviews. The second aim was to obtain new inputs and insights from stakeholders about how to build these transition pathways. In total, eight stakeholders attended the transition pathways workshop. All apart from one participant had previously been involved with my research. Four of them had participated in the future visons workshop and had already been interviewed. The three remaining participants also had been interviewed. The professional activities of the participants were one researcher, one consultancy/certifier, three government representatives, two from industry/investors and one farmer.

Similar to the future visions workshop and interviews, the transition pathways workshop is an adaptation of (Quist, 2013) and (Quist, 2016) methodology (see section 3. 2. 2. in this chapter). In the transition pathways workshop, I worked with participants to refine the preliminary results from the future vision workshop and interviews with a focus on understanding the viability of the sustainability measures and the interactions between them.

I wrote on paper and displayed the preliminary results on the wall, i.e., problems of the Brazilian agri-food system, measures of sustainability, elements of sustainability and principles of sustainability. Using these results, I made a general presentation and then I started the workshop activities. Feedback from all stakeholders and workshop outcomes were recorded onto paper and displayed on the wall. appendix 9 shows an overview and explain the material used in the workshop.

General presentation

- Welcome
- Recap the aims of my research project;
- goals and guidelines for the workshop;

- presentation of the transition model (based on stakeholder's feedback) highlighting measures to achieve sustainability of the Brazilian agri-food system.

<u>Working session</u>

1. Working in two groups of four participants divided randomly: One group discussing bottom up measures and the other discussing top down measures to bring sustainability to the Brazilian agri-food system.

Support material and tasks

Each group discussed negative and positive aspects of the transition model, the missing elements of the measures and the whole transition model. For each measure, groups discussed the section in the example given in the table 7 (see the original paper used to collect the stakeholder's input in the appendix 10). The 'bottom up and society participation group' discussed 19 measures (S1, S2… S19, see appendix 9), while the 'top down and government group' discussed 22 measures and created another one, accounting for 23 measures in total (G1, G2… G23, see appendix 9).

Table 7. Example of the support material for the discussion of measures of sustainability

S1. Bottom up and participatory measure (number one) – Sustainable, democratic and decentralized territorial planning (ZEE, river basin committees, climate adaptation, law of cities, municipal master plan)

Ranking of the sustainability elements* affected by the measure : K, I, G, H, C, M, B, E

Interaction with other measures:

- Dependent: S19, S11
- Counterproductive:
- Complementary:

Probability of implementation (high, medium or low) : Medium

Implementation term (long, > 15 years; medium, < 15 years and > 5 years; short, < 5 years): Long

Conditions of implementation:

Comment:

Priority: one stick of priority

* The elements of sustainability based on results from the future visions workshop and interviews are identified with the letters below:

- Production and consumption of food with a focus on small-scale family agriculture (A), local (B), agroecology (C) and diversity of products (D);
- Monoculture, livestock and GMO production (conventional agriculture) present certified better management practices and private financing (E);
- Valorisation, use and conservation of socio-biodiversity and traditional knowledge (F);
- Society responsible for sustainable co-production and consumption (G);
- Principles of sustainability present in public policies and in production and consumption chains (H);
- Decentralized and democratic decision-making spaces (I);
- Independent and free media and culture (J);
- Multifunctional agriculture based on democratic territorial planning (K);
- Access to adequate food and without wastage (L);
- Repopulation and permanence in rural areas (M);

2. General assembly to present and discuss the outcomes

B. Selecting the unit of analysis

I perform the inductive content analysis following the same preparation phase process of the deductive content analysis in this chapter. I read several times the entire compilation of the workshops and interviews highlighting important portions of raw text and quotes, and finally selecting a word or a short phrase to represent the meaning of a specific question or topic, as suggested by Alexander (2016).

Future visions workshop

The only difference for the selection of the units of analysis from the future visions workshop are the questions selected. For the previous deductive content analysis I use only the first two questions discussed over the workshop about the elements of sustainability (see table 2). Here, for the inductive content analysis I use all the information collected in the Future visions workshop with the exception of the first two questions (see table 2 in this chapter) to build the transition pathways.

Stakeholders Interviews

I use all the information collected by the interviews and I use exactly the same units of analysis of the deductive content analysis process. For each interview (Researcher 1 – R1, ONG 1 – O1; Researcher 2 – R2, etc), I highlight parts of the transcribed text (words, sentences) that represented the units of analysis, i. e., core ideas representing the answer for each question/issue (A1. Problem, A2. Solution, A3a. Institutional sustainability goals, A3b. Personal goals, B1. Institutional compliance to sustainability, B2. International agreements, B3. National policy). Then, I include the core ideas from each stakeholder in the same Excel spreadsheet per question (A1, A2…)(table 3).

Chapter 3

Transition pathways workshop

The information used in the Transition pathways workshop comes from the data of the Future visions workshop and the interviews, plus the results of the chapter 4. From these results, I compile information about problems of the Brazilian agri-food system, measures and insights for sustainability, elements of sustainability and principles of sustainability. The units of analysis of the Transition pathways workshop include the new insights given by participants during the workshop about all information compiled and organized from the Future visions workshop and interviews.

C. Organising phase

The process of organizing the qualitative data includes **open coding, grouping data and creating categories**. According to Elo & Kyngas (2008) the **open coding** consists in writing notes and headings in the text while reading it. As Alexander 2016 recommends, I read the workshop results and interview transcripts in its entirety several times. Reading the written material several times is important to immerse the researcher in the data (Burnard, 1991). In the coding process, I highlight portions of raw text, quotes and concepts that I found important, and chose a word or a short phrase to represent the meaning of it, the units of analysis (Alexander, 2016). The units of analysis come from the Future visions workshop and interviews, mainly from the what-how-who questions (Quist, 2013), that explore directly the required changes, measures and stakeholder involvement for the improvement of the sustainability of the Brazilian agri-food system. However, the entire material from the workshops and interviews were repeatedly revised in order to identify measures and narratives constructed from stakeholders' opinions to solve problems in the Brazilian agri-food system and achieve its sustainability. **Grouping data** is a collapse of codes (units of analysis) with similar concepts into the initial categories (Alexander, 2016). "**Creating and defining categories** is to provide a means of describing the phenomenon under investigation, to increase understanding and to generate knowledge" (Cavanagh, 1997, p.9). The set of measures (solutions) to improve the sustainability of the agri-food system given by stakeholders are categorised into twelve strategies (see section 6.3.2, chapter 6), i.e. a strategy is a group of measures following a same theme. These

measures are results of the process of grouping units of analysis from the future visions workshop and the interviews.

D. Reporting the analysing process and the results

I use the information collected at the future visions workshop, interviews and transition pathways workshop to develop the Backcasting analysis (Quist, 2013, Quist, 2016) in three stages: **what-how-who analysis (organizing phase), development of transition pathways for the sustainability of the Brazilian agri-food system (reporting phase) and scenario sustainability analysis (reporting phase).** The **what-how-who analysis** presents the measures and their categorization into strategies (see section 6.3.2, chapter 6). The **Development of transition pathways for the sustainability of the Brazilian agri-food system** (section 6.3.3, chapter 6) describes the mechanism and steps to develop the transition pathways for the sustainability of each future vision. I create the transition pathways interpreting which and how stakeholders' measures and solutions to improve the sustainability of the agri-food system would apply to each future vision. I define the key strategies to implement the vision, the most important measures for each strategy and the main interactions between the most relevant strategies and measures. The **Scenario sustainability analysis** (section 6.3.3, chapter 6) is the analysis of stakeholders' feedback regarding the opportunities, barriers, who would contribute to and who would oppose improving the sustainability of the Brazilian agri-food system. For each element of these variables, I classify if it has low applicability, if it is applicable or if it has high applicability for both visions. For example, the opportunity for mobilising society is classified as low applicability for the In-depth reform vision aims and strategies and high applicability for the Radical transformation ones (table 12, chapter 6). I also describe the relation of each vision to the problems and solutions to improving the sustainability of the Brazilian agri-food system. Finally, I analyse the results of the hierarchical indicator framework developed and assessed in chapter 4 with the core ideas of both visions. These analyses are important to understand the elements that would challenge or strengthen the probability of implementation of each vision. The consideration of the indicators from chapter 4 is essential to evaluate the sustainability of each vison.

3. 2. 4. Chapter 7: Alternative transition pathways and policy prescription

Finally, I propose, in chapter 7, alternative transition pathways and policy prescriptions for the sustainability of the Brazilian agri-food system, combining, analysing and discussing the outcomes of the whole thesis. In order to address this aim, I structure the discussion in three sections. First, I explore the two main drivers of the global agri-food system, according to researchers and international agencies: the need to (1) increase food production (2) reduce the negative impacts of production. Then I present the gaps in the literature and outline my contribution based on the approach developed in this thesis (section 7.2). In the second section, I present specific problems and solutions for the Brazilian agri-food system, synthesizing the results of the framework used in this research (section 7.3). In the third section, I make recommendations for transition pathways to improve the sustainability of the Brazilian agri-food system, including limitations and refinement of the research (section 7.4).

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4

How sustainable is the Brazilian agri-food system? Assessment from a novel indicator framework

4.1. Preamble

Three questions structure this chapter: What is sustainability in agri-food systems? How can it be assessed? How can it be made applicable and relevant for actors in the field? These questions come from three gaps in the literature review (see Chapter 2): the lack of a clear and broad concept of agri-food systems (gap 1) and its sustainability (gap 2), and the lack of a framework to assess agri-food systems (gap 3). In order to answer the questions I develop a hierarchical indicator framework to assess sustainability and evaluate the Brazilian agri-food system. I apply a novel approach to this framework to guarantee policy relevance and applicability of the indicators by linking them with the goals of two international agreements (MDGs and Aichi targets). The indicator framework may be an alternative tool to link knowledge and practice, enhancing communicability and partnership for the improvement of the governance in agri-food systems.

4.2. Methodology implementation

This chapter is part of the problem orientation step, the first of three steps of the participatory backasting framework adapted from Quist (2016) to build transition pathways for the sustainability of the agri-food system (figure 1, chapter 3). The problem orientation consists in a context analysis from the literature review (chapter 2) and the development of an indicator framework to deepen the understanding of the sustainability of the Brazilian agri-food system made in this chapter. The methodology and structure of the four stages to assess the

sustainability of the Brazilian agri-food system is explained in chapter 3. They are: describing the agri-food system and the concept of sustainability (3.2.1.1), defining how the sustainability concept applies to the agri-food system (3.2.1.2) and proposing a mechanism to identify the main challenges and link indicators of sustainability of the agri-food system to policy and goals (3.2.1.3) and analysis (3.2.1.4). In this chapter, I present and analyse the results of the hierarchical indicator framework.

4.3. Results

I propose an indicator framework that gives an overview of the sustainability of the Brazilian agri-food system and highlight the main challenges each criterion has to undertake to accomplish the goals and targets of sustainability established by MDG and Aichi targets. All indicators mentioned in the results are presented briefly in table 8, in detail in appendix 1 and in summary in figure 5. Overall, none of the criteria presents a good performance in sustainability (figure 5). Only 5 out of 51 indicators classify as "high improvement" in their performance of sustainability (table 9, figure 5). Four of them are improvements in the equity & social welfare criterion figures and one in economic stability/investment. Sixteen classify with "some improvement" and 30 with "no improvement" (table 9, figure 5). The results of the hierarchical indicator framework corroborate with the general critique stated by Padua (2004) and specific ones cited from several authors below. The Brazilian agri-food system is depleting natural resources, increasingly polluting the environment with agrochemicals (ABRASCO, 2012), threatening biodiversity and the provision of ecosystem services (IUCN, 2011, INPE, 2017, MMA, 2017,) threatening traditional communities (GGN 2017b, Orso, 2017, Santos, 2018, Ribeiro et al. 2018, Lastoria et al. 2018, Cimi, 2018)and weakening resilience and diversity of crops (Friedrich et al. 2018). On the other hand, it has positively guaranteed access to food and literacy rates have improved, even in rural areas (IPEA 2014). These improvements are very important and commendable; however, the improvements provide basic inclusion (e.g. minimum level of dietary energy, indicator 2) rather than significant progress in equity. Massive challenges in equity (IPEA 2014, MDA, 2009, Singer, 2009) still need to be addressed in this area. Agribusiness is extremely important for the Brazilian economy (trade

balance and GDP) (CEPEA-USP, 2017, MAPA, 2016, OECD 2015), however, Brazilian export earnings also generate a very uneven concentration of wealth and power by a small, conservative group (Mattei, 2018, Castilho, 2018, also see "BBB" and "ruralistas" in chapters 2, 5 and 6). According to stakeholders (chapters 2, 5 and 6), this group feeds the status quo, and it is one of the strong forces to prevent the transition towards a sustainable Brazilian agri-food system. See below the description of the indicators by criteria and a further discussion of the chapter.

Table 8. Results from the Hierarchical Indicator Framework

ID	Criteria	Indicator	Policy Relevance	Performance
1, 2		Diet	MDG	High Improvement
3, 4		Literacy	MDG	High Improvement
5, 6		Income	MDG	Some Improvement
7, 8, 9		Literacy	MDG	Some Improvement
10, 11		Gender equality	MDG	Some Improvement
12		Water access	MDG	Some Improvement
13		Sanitary access	MDG	Some Improvement
14, 15	Equity/Social welfare	Share of consumption	MDG	No Improvement
16		Gini Index	MDG	No Improvement
17		GDP share	MDG	No Improvement
18, 19		Employment share	MDG	No Improvement
20		Gender equality	MDG	No Improvement
21		Land access	Aichi Targets	No Improvement
22		Slavery	MDG	No Improvement
23		Dietary share	MDG	No Improvement
24, 25		Dietary share	MDG	Some Improvement
26		Trade Balance	N. A.	High Improvement
27		Agriculture % GDP	N. A.	Some Improvement

28	Economic stability/ Investment	Commodities production	N. A.	No Improvement
29		Trade Balance	N. A.	No Improvement
30, 31, 32		Infrastructure	N. A.	No Improvement
33	Culture/ Tradition	Traditional knowledge	Aichi Targets	No Improvement
34		Linguistic diversity	Aichi Targets	No Improvement
35		Genetic diversity	Aichi Target	No Improvement
36		Sustainable management	Aichi Targets	No Improvement
37	Ecosystem services/ Biodiversity Conservation	Land use	MDG	Some Improvement
38		Fish conservation	MDG	No Improvement
39		Protected areas	MDG	No Improvement
40		Species extinction	MDG	No Improvement
41, 42		Ecosystem services	Aichi Targets	No Improvement
43, 44, 45	Use of resources/ Pollution	CO2 emissions	MDG	Some Improvement
46, 47, 48, 49		Water quality	Aichi Targets	No Improvement
50		Fertilizers	Aichi Targets	No Improvement
51		Pesticides	Aichi Targets	No Improvement

Source: FAOStat (2017), MAPA (2015), MMA (2017), IPEA (2014), IUCN (2011), Sparovek (2011), MDA (2009), IBGE (2012), Santos (2007). See detailed information of indicators in appendix 1.
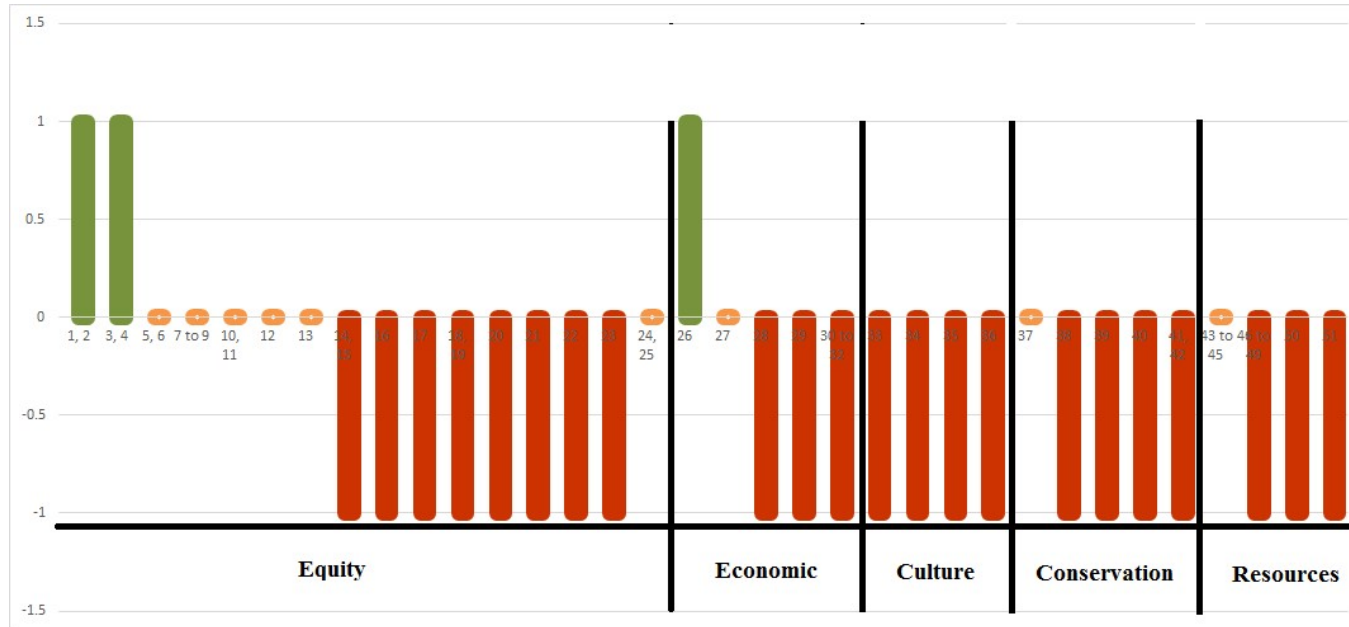
Figure 5. Overall summary of the performance of criteria and indicators of sustainability of the Brazilian agri-food system

Table 9. Performance of criteria according to the level of compliance with sustainability

Criteria / Performance	High improvement	Some improvement	No improvement
1. Equity/Social Welfare	4	9	9
2. Economic stability/ Investment	0	4	3
3. Culture/ Tradition	0	0	4
4. Ecosystem services/ Biodiversity Conservation	0	1	5
5. Use of resources/ Pollution	0	3	6
Total	4	17	27

4.3.1. Equity & social welfare

This criterion includes almost half of the number of indicators found and explored in this research, 22 out of 51. This criterion is the only one that contains indicators (4 out of 22) with high improvement. This means that not only were the targets achieved, but that the achievements are ideal. For instance, indicator one (ID 1), achieved the top status recommended by FAO in prevalence of underweight children under-five years of age. Similarly, some indicators related to the supply and access of food and literacy rates show better performance, i.e. "high improvement" (indicators 1 to 4). Nine indicators show "some improvement" on their figures (indicators 5 to 13). These indicators are also associated with increases in literacy rates in addition to poverty prevention and access to water and sanitation. The biggest challenges ("no improvement") for the development of this criterion are regarding distribution of income and land among the population, quality and rights of employments, percentage of women in parliament. Nine indicators show "no improvement" because of their negative or low performance in these subjects (indicators 14 to 22).

In general, the performance of indicators in rural areas are worse than those in urban areas, as verified by the indicators 3, 4, 5, 6, 8, 9, 12, 13, 18, 19. Rural areas perform worse than urban areas in literacy, employment and worker's rights, poverty

prevention, access to water and sanitation. For this reason, these indicators are very important to understand the sustainability in the agri-food system and highlight the disparity between rural and urban areas. For instance, literacy is one of the main instruments of the MDGs to assess the equality between men and women. In Brazil, inequality in education affects men. In 2012, the ratio of girls to boys in secondary and tertiary education were 1.25 and 1.36, respectively (indicator 10). Conversely, women's success in education is still not reflected in terms of total employment-to-population ratio and the proportion of seats held by women in national parliament (indicators 18 and 20). Furthermore, the lack of good education and jobs in rural areas contribute to the exodus of young people who migrate from the countryside in search of better opportunities in urban centres.

In terms of diet, the average protein supply from animal and non-animal origin is increasing for Brazilians, while the share of dietary energy supply derived from cereals, roots and tubers is decreasing (indicators 23, 24, 25).

4.3.2. Economic stability & investment in infrastructure, research and technology

This criterion does not have similar targets or goals in MDG or Aichi targets; however, they are essential for the development of the agri-food system. Seven indicators assess this criterion. Four of them present "some improvement" (indicators 26 to 29) and three "no improvement" (indicators 30 to 32) in their performance of sustainability.

Brazil is one of the main exporters of agricultural commodities in the world. This export is highly important for the country's balance of trade. According to MDA (2009), from 1995 to 2006, the balance of trade relating to Brazilian agriculture was very positive, from 7.3 to 32.6 billion dollars (indicator 26). In the same period, agricultural exports comprised 28.7 to 26.8% and imports 12.5 to 4.9% of the entire Brazilian trade. The Brazilian Ministry of Agriculture states that the share of agricultural exports increased from 37.9% in 2010 to 46.2% in 2015 of total exports (MAPA, 2015). Even with the increase in the share of exports, the participation of agribusiness supply chains in total Brazilian GDP had a slight decrease, from 25.95%, 22.81% and 22.54% in 1995, 2006 and 2013, respectively (indicator 27). According

to data from FAOStat (2017), the value of food imports over total merchandise exports (%) is very low, rising from 2% to 3% from 2006 to 2011 (indicator 29). These positive economic results mainly come from a small number of commodities (indicator 28). For instance, soybean (36.76%), maize (20.88%) and sugar cane (14.27%) corresponded to 71.88% of the total crop area harvested, and only 10 commodities were responsible for 90.98% of the total area harvested (indicator 35, FAOStat, 2017). The total net production value, including meat for 2012 was 136 billion dollars (constant 2004-2006 1000 I$) (FAOStat, 2017). Only a few products (meat indigenous cattle, sugar cane, soybeans, meat indigenous chicken, milk whole fresh cow) were responsible for 68.43% of this value (indicator 28).

The Brazilian infrastructure still needs a considerable amount of investment in order to be able to effectively transport agricultural production. In 2011, the percentage of paved roads over total roads was 13.5, road density 18.6 per 100 square km of land area, rail-lines density 0.4 per 100 square km of land area (respectively, indicators 30, 31 and 32).

4.3.3. Preservation of culture & tradition

All results for this criterion related to the maintenance of local culture and tradition have a "no improvement" performance. One example is the area of agriculture under sustainable management, where the percentage with organic agriculture for the years 2006, 2009 and 2011 was insignificant; 0.19, 0.34 and 0.25% respectively (indicator 36). Another indicator from the Aichi targets to measure the maintenance of local culture/tradition is the trends of linguistic diversity and number of speakers of indigenous languages, which is massively affected by the expansion of agribusiness. It is estimated that around 1000 languages and dialects were spoken before Europeans arrived in the Brazilian territory. Currently, there are 231 indigenous peoples in Brazil, around 600 thousand people speaking around 180 languages and dialects (indicator 34). Negative figures are also found for safeguarding genetic diversity (indicator 35).

4.3.4. Ecosystem service provision & biodiversity conservation

Changes in land use due to the agricultural sector have been the leading cause of biodiversity loss (Foresight, 2011). For this reason, one of the indicators I use is the proportion of land area covered by natural vegetation, which is also adopted by the MDGs and Aichi targets to monitor the loss of habitats (indicator 37). This was the sole indicator with "some improvement" for this criterion. According to IUCN (2011), in 2012 4.63 million km^2 was covered with forests, out of a total of 54.4% of the national territory, and the legal Amazon deforestation decreased by 83% from 2004 to 2013 (INPE, 2017). However, the amount of remnant vegetation varies per Biome. Atlantic Forest had the smallest percentage (22.25% until 2008, MMA, 2017) and the Amazon the biggest (nearly 84% until 2007; Santos et al., 2007). The other indicators of this criterion classify as "no improvement", because of the constant risk of extinction of species (indicators 38 and 40), the low protected areas level taking into account all biomes (indicator 39) and the degradation of natural habitats (indicators 41 and 42).

4.3.5. Use of natural resources & pollution

Agriculture is one of the components of environmental change, mostly because of nitrogen oxides (NO_x) emissions from fertilizer use, methane (CH_4) emissions from livestock and land use change (Foresight, 2011). For instance, the indicators related to emissions of CO_2 equivalent (CO_2eq) are the only ones in this group which present "some improvement" of performance (indicators 43, 44 and 45). A reduction of 38.7% of CO_2eq emissions was observed from 2005 to 2010. The contribution of agriculture and cattle ranching for the total CO_2 emissions decreased from 78% to 57% in this period, mainly because of the reduction of CO_2 emissions due to changes in land use (deforestation). The rest of the indicators for this criterion present "no improvement" performance to achieve the sustainability targets. The quality in water (also affected by the leaching of nutrients from agricultural practices) has not achieved the level required for 95% of the water bodies (indicators 46, 47, 48 and 49). There was an increase in the use of tonnes of nutrients per 1000 ha for Nitrogen (138.40%) and Phosphate (114.27%) from 2002 to 2010 (indicator 50). For the same period, the consumption of tonnes of Potassium (K_2O) arose 133% (indicator 50). From 1991 to

2001, the use of pesticides per 1000 ha increased 328% (indicator 51), making Brazilian agriculture environmentally more unsustainable and economically dependent on international inputs. Also, the average consumption of agrochemicals has increased in relation to the planted areas, from 10.5 litres per hectare (l / ha) in 2002 to 12.0 l / ha in 2011 (indicator 51).

4.4. Discussion

Research questions

What is sustainability in agri-food systems? As stated by Binder et al. (2010), the general vision of sustainability privileges environmental and technical aspects. According to some authors (FAO, 2017; OECD, 2015; Foresight, 2011; IAASTD, 2009, Foley et al., 2011; Godfray & Garnett, 2014) the major challenges of the global agri-food system are to secure access to adequate food for all people and reduce environmental impacts. This discourse of food security feeds neoliberal arguments of free market and new technological revolution as solutions for the challenges of the agri-food system (Hopma & Woods 2014). However, overemphasizing this discourse of food security based on technological improvements of conventional agriculture can neglect essential elements for the sustainability of the agri-food system, such as dependence upon external inputs, inequalities and injustices. To avoid this reductionism and contribute to the improvement of agri-food system assessments, I consider a broad concept of sustainability in this study. Based on the literature review I assume that an agri-food system is more sustainable as much as it addresses the multi-functionality and multidimensionality of a defined territory. The presence of these two perspectives can be guaranteed through three outcomes of agri-food systems: environmental quality, food security/sovereignty and human wellbeing. In other words, the sustainability of an agri-food system would be possible only when these three elements are at their fully functional quality and capacity.

How can it be assessed? To assess the sustainability of agri-food systems, taking into account their complexity, it is necessary to use a variety of indicators as observed in the research developed by Dantsis et al. (2010), Corbiere-Nicollier (2011), Ericksen

(2008), Verburg (2014) and by international policy agreements like the MDGs and Aichi Targets. I structure these indicators in a hierarchical indicator framework in order to guarantee applicability and policy relevance.

How to make it applicable? To be applicable for stakeholders on the ground, the indicator framework has to connect the sustainability perspective to relevant policy instruments. The clear connection of the indicator framework proposed in this study with the MDGs and Aichi targets highlights its relevance and applicability as a tool to orient and monitor policy instruments. For example, the use of the indicator with the target (MDGs) to reduce the "proportion of population below minimum level of dietary energy consumption" (indicator 2). Other indicators, criteria and targets can be added or replace the ones suggested in the hierarchical indicator framework, depending on the aims of use of the framework (for example, watershed committee, national and local policies, multi stakeholder initiatives etc). It is important to keep the link between knowledge and practice, and to incorporate traditional knowledge in the framework.

Some strengths of the hierarchical indicator framework are:

- It responds to a clear objective (sustainability of agri-food system);

- Has an objective with solid conceptual definition;

- Is connected to policy relevant instruments;

- Has a clear structure connecting objective, criteria, indicators and instruments of policy and management (hierarchical tool, figure 4, chapter 3);

- Is flexible to include or exclude indicators;

- Has indicators that can be developed, updated and monitored;

- Links knowledge and practice.

- The results from the criteria can be narratively explained in order to improve the communicability of the tool.

Chapter 4

Sustainability of the Brazilian agri-food system

I demonstrate how to apply the hierarchical indicator framework by assessing the sustainability of the Brazilian agri-food system. The hierarchical analysis is flexible to explore how different scales of sustainability can be understood and interact with each other. For instance, the principles of sustainability (environmental quality, food security/sovereignty and human wellbeing) can be explored separately or compared with each other. The same exploration can be made by criteria or indicator level. As a result, the status of sustainability of specific areas, elements or indicators can orient where actions should be focused on. The aim of this chapter is to discuss the tool and give a brief overview of the status of sustainability of the Brazilian agri-food system, identifying necessary improvements in the selected criteria and indicators presented in this research. More detailed discussion of the challenges and ways to improve sustainability are presented in chapters 5, 6 and 7.

The assessment of the Brazilian agri-food system shows that there needs to be a considerable effort made to improve the status of sustainability and comply with the responsibilities assumed internationally with the goals of the MDGs and Aichi targets. Similar efforts must be made to maintain the quality and status of the indicators considered "high improvement" or continue to improve those, which have presented "some or no improvement" performance. More ambitious improvements in sustainability would be required if the SGDs were considered in this analysis (see chapters 6 and 7). In this new international agreement for sustainability, a specific goal for sustainable agriculture is established, as well as more detailed goals and targets for equity, sustainable consumption and production and so on.

The results corroborate with publications, which take into account a broad and inclusive perspective of sustainability, as used in this research (such as Martins-Torres & Rosset, 2014, Padua, 2004). Other reports/studies which give more relevance to economic growth, market and technology development (Embrapa, 2014; OECD, 2015; MAPA, 2015), sometimes neglect deep social and environmental considerations, and tend to be more positive about the sustainability of the Brazilian agri-food system (see chapters 2, 6 and 7).

Therefore, below I present some narratives to improve the sustainability of the Brazilian agri-food system based on the hierarchical indicator framework results:

For *equity and social welfare,* for example, it is valuable to understand that the positive improvements of some indicators of this criterion are results from federal government programmes to combat hunger and increase access to education (see Zero Hunger Project in chapter 2 and FAO, 2010). These improvements are also part of the Brazilian commitment to accomplish the goals and targets of the international sustainability agreements (specifically, the MDGs and Aichi Targets). Although the improvements made by Brazil against these indicators is commendable, there is still a huge effort needed in order to overcome the challenges to improved sustainability of the Brazilian agri-food system (see also ABRASCO, 2012, MMA, 2017, Cimi, 2018, Friedrich et al. 2018). Special effort has to be done in rural areas, since the indicators from these areas have worse performance in comparison to the urban ones (IPEA, 2014). In the *equity and social welfare* criterion, one indicator identifies the share of women in wage employment in the non-agricultural sector. This indicator is evidence that the MDGs assume that the agricultural sector offers worse work conditions (especially for women) than other sectors. Consequently, more effort should be done to reverse this situation. In addition, under equity, in all literacy indicators, women performed better than men, essentially in rural areas. Policies should incentivize the inclusion of men, mainly at higher levels of literacy where the differences are greater. However, the main challenge found for this criterion and for the whole Brazilian agri-food system is the distribution of income, wealth and power (see also Mattei, 2018, Castilho, 2018, Cimi, 2018). Low performances in indicators such as the Gini index, land distribution, slave labour and the proportion of seats held by women in the national parliament reveal Brazil to be a very unequal country. Indeed, the concentration of power (as demonstrated by Fuchs *et al* 2015) is one of the principal impediments for the improvement in other sustainability criteria. These results endorse Padua's (2004) statement that the Brazilian agricultural model, which privileges large farms and monoculture for exportation of exotic products, on the one hand contributes to economic growth, and on the other hand, generates serious socio-environmental impacts (see chapter 6 and 7). The *equity* criterion is central to the sustainability of the whole agri-food system. Improvements of literacy rates, quality of life and distribution

of land, income, wealth and power in Brazil are essential and prerequisites for the improvement of other criteria (see chapter 6).

Indicators with "some improvement" from the *economic stability & investment* criterion are related to the economic success of the Brazilian agribusiness sector. The sector reached almost 50% of the Brazilian total exportation in 2015 (MAPA, 2015) and 22.54% of the Brazilian GDP in 2013 (CEPEA/USP, 2017). The economic success of agribusiness is controversial because of the effects on the concentration of land and power (see also MDA, 2009). There are holdings of over 1000 hectares, which account for only 1% of the total number of farms, occupying / accounting for 44% of farmland in Brazil (OECD, 2015). Around 87% of Brazil's allocation credits between 2011/12 and 2013/14 were provided to large and medium-scale commercial producers and only 13% to small family farmers (OECD, 2015). Further considerations of the positive and negative economic, social and environmental impacts of Brazilian agribusiness are made in chapters 2, 6 and 7. The low investment in infrastructure is responsible for worsening the performance of this criterion (FAOStat, 2017). However, the necessity of improvements in the infrastructure sector can also be seen as an opportunity for economic development and job creation.

For preservation of *culture & tradition* criterion, it is necessary to keep and incentivize the use of sustainable agriculture, with low demand of inputs, as a key mechanism to support traditional communities and to maintain the culture and quality of life of peasants. Traditional communities and small family farmers are responsible for conserving the genetic diversity of cultivated plants (UICN, 2011). As the agriculture of high inputs and mechanization has become mainstream in Brazil, the essential agri-food system function to maintain sociocultural diversity and the ability of traditional communities to protect agrobiodiversity has been lost. The unbalanced preference of Brazilian agricultural policies (see chapter 2) which gives massive support to high input monoculture of a few exotic products for export, directly threatens the capacity of traditional communities to maintain their culture, knowledge and conserve endogenous cultivated species (see also Lastoria at al., 2018, Cimi, 2018).

In Brazil, the agricultural sector has been the main driving factor of conversion of native vegetation and displacement of traditional communities (Padua, 2004; Martins, 2014). This is an important aspect, which also involves the criteria *ecosystem service*

provision & biodiversity conservation for the loss of biodiversity and *use of natural resources & pollution*, because deforestation has been the main component of an important MDGs environmental indicator, CO_2 emissions. Policies and strategies to reduce CO_2 emissions have to consider these relationships. The unique indicator with "some improvement" from the "*ecosystem services provision & biodiversity conservation* criterion is related to the high proportion of land area covered by forest (61%, FAOStat, 2017) and the reduction of deforestation in the Amazon (INPE, 2017). This indicator is not considered "high improvement" because deforestation is still not under control in Amazon and other biomes. The Brazilian savanna (Cerrado) has been constantly deforested by the expansion of agriculture. Moreover, the proportion of forest remnants (2008) is much less in biomes such as Atlantic Forest (22.25%) and Pampa (36.06%) than Amazon (86.74%) (MMA, 2016). Because of frequent disturbance, degradation and pollution originated by the production and consumption of food, loss of biodiversity and the quality of ecosystems services have been highly affected (see also IUCN, 2011, MMA, 2017). The environmental quality is essential for well-functioning food production.

Indicators related to the reduction of CO_2 emissions are the only ones with "some improvement" in the *use of natural resources & pollution* criterion. The increase in the use of fertilizers and pesticides for mainstream agricultural production in Brazil are a real risk for the country's food sovereignty. The main reasons are the high costs of production, the contamination of food and environment (especially water) and the external dependency on inputs, since Brazil is highly dependent in imports of nutrients and pesticides (ABRASCO, 2002).

For the improvement of the sustainability of the Brazilian agri-food system, i.e. the provision of environmental quality, food security/sovereignty and human wellbeing, all challenges briefly described for each criterion have to be addressed and amended. According to the Millennium Ecosystem Assessment (2005a), the role of agriculture is not only in productive and social aspects but also in preserving or endangering ecosystem functions. Following the recommendation of IAASTD (2009), the purpose of agriculture has to be multi-functional. More than food production, it must involve functions such as regulating water, controlling erosion and support services such as soil formation, providing habitats for wildlife, as well as contributions to cultural

activities such as use and preservation of landscapes and spiritual sites. Additionally, the changes required for a more sustainable agri-food system should be built under the pillars of food sovereignty, where the right of peoples and sovereign states to democratically determine their own agricultural and food policies are guaranteed Millennium Ecosystem Assessment (2005a).

I highly recommend the use of the hierarchical indicator framework to contribute to filling the gap of the lack of an applicable and policy relevant tool to address and monitor the sustainability of agri-food systems by governments (federal, regional and local), multi stakeholder initiatives and social movements. Current studies and information are lacking a clear definition of the concept of sustainability, applicability and connection with policy instruments. The tool also can serve as a standard base to reduce limitations on data availability, concepts and methodology consensus, robustness, standardization, accessibility, communicability, etc. One of the difficulties of promoting sustainability is the establishment of a common tool, concepts and objectives to connect knowledge, planning and action. The clear establishment of an objective based on a solid concept can overcome the problems regarding the different temporal scale or the abstract and conflicting interpretation of indicators. The importance of this research is to contribute to the development of these tools to connect science and policy and to improve the sustainability of agri-food systems, specifically for Brazil. Scientists and practitioners have to work together to understand, address gaps, produce new knowledge and integrate them with the requirements of policy instruments and social movements to promote sustainability. This information also can be used as a platform to support strategies for civil society to promote social change and empowerment.

4.5. Conclusion

Adapting existing knowledge, I develop a tool that contributes to fill the gap identified in the literature. This is a lack of policy relevant and applicable instruments to deal with the complexity and challenges around understanding and improving sustainability of agri-food systems.

The hierarchical indicator framework is a set of indicators that describe the quality of essential criteria to guarantee the well-functioning of the 3 outcomes of sustainability in agri-food systems: environmental quality, food security/sovereignty and human wellbeing. I ensure the policy relevance of the tool by linking the assessment of indicators with goals and targets from international agreements. The tool is flexible to include or exclude indicators or policy instruments depending on the task established. The indicator framework can be an alternative tool to link knowledge and practice, enhancing communicability and partnerships for governance, using an objective to be reached and a clear concept definition. The quality of indicators can be improved, updated and monitored. It sets a clear objective and uses a clear definition of concept of sustainability.

The use of the tool was demonstrated by a brief overview assessment of the status of the sustainability of the Brazilian agri-food system, highlighting strengths and challenges for its improvement. Better performance is observed for indicators related to the access of food, such as hunger eradication, and an increase in the quality of the Brazilian diet and literacy. On the other hand, improvements are required for indicators related to environmental over-extraction and degradation, GHG emissions, investment in infrastructure, use of fertilizers and pesticides, dependency on oil and social inequality.

5

Sustainable future visions for the Brazilian agri-food system

5.1. Preamble

This chapter answers the question what do future visions for a sustainable Brazilian agri-food system by 2030 look like from the perspective of a group of stakeholders working on this issue in Brazil. This question intends to fill gap 4 (see chapter 1) identified in the literature review, i.e. the need for and lack of participatory approaches proposing pathways to achieve sustainability in agri-food systems. I frame the discussion of sustainability with the support of results found in chapter 4, which assess the sustainability of the Brazilian agri-food system and the literature review findings in chapter 2. Using the participatory backcasting framework described in chapter 3, I distinguish two future visions, based on conflicting or contrasting ideas expressed by stakeholders in specific questions explored in one workshop and 26 interviews. chapter 6 presents the ensuing transition pathways to achieve sustainability in each one of these visions, viability of implementation and trends.

5. 2. Methodology implementation: Generating a future vision

The aim of the next step is to generate and analyse a sustainable future vision for the Brazilian agri-food system, named **generating future vision** (see methodology implementation in chapter 4). According to Quist et al. (2013: 46), the vision "is based on the consolidated problem perception…as well as the guiding sustainability principles". The problem perception and the sustainability principles of the agri-food system come from the strategic problem orientation step and feed the two first stages to generate the future vision, the context analysis and the normative goal (see chapter 2, 3, 4 and figure 1). In other words, chapters 2, 3 and 4 address and are pre-requisites of the two stages of the generating future vision step. The third stage of step 2 (see

chapter 4 and figure 1), also named generating future vision, uses one workshop and 26 interviews (see section participatory approaches in this chapter) with stakeholders to produce two future visions (In-depth reform and Radical transformation). I use the participatory backcasting approach with the support of content analysis (see methodology in the section 3.2.2 of chapter 3) to build narratives of the two future visions.

5. 3. Results

In this chapter, I generate two future visions (step 2, figure 1, chapter 3) that work as a reference for the identification of transition pathways for the sustainability of the Brazilian agri-food system (see chapter 6). As mentioned in the chapter 3, I use the participatory backcasting approach with the support of content analysis. Following the deductive content analysis (see section 3.2.2.2, chapter 3) firstly, I explain the item B. Selecting the unit of analysis (5.3.1 in this chapter) from the outcomes of the future visions workshop and the interviews with stakeholders. Secondly, I explain the item C. Organizing phase (5.2.2, this chapter). Finally, I describe the item D. Reporting the analyzing process and the results (5.3.3, this chapter) produced for the In-depth reform and Radical transformation future visions. Before describing the visions, I synthetize and give examples of some of the key elements responsible in order to split the results into two different narratives.

5. 3. 1. Selecting the unit of analysis (item B of the deductive content analysis, chapter 3)

As suggested by Alexander (2016) and Burnard, (1991), I select as units of analysis important portions (word or short phrase) of raw text and quotes from the future visions' workshop and interviews.

Future visions' workshop: "elements of sustainability"

Table 10 shows the "elements of sustainability" (**presented without any change**) considered by participants of the 'future visions' workshop necessary to improve and

accomplish the normative goals of sustainability for the Brazilian agri-food system (the first question of table 2, chapter 4). The elements of sustainability are the ideas generated by the brainstorming and discussion activity, recorded onto paper and stuck on the wall by participants (see photo from one of the three groups of the Future visions' workshop in the appendix 5).

Stakeholder interviews

The units of analyses are core ideas representing the answer for the question/issue: A1. Problem, A2. Solution, A3a. Institutional sustainability goals, A3b. Personal goals, B1. Institutional compliance to sustainability, B2. International agreements, B3. National policy (see table 3, chapter 3). Each one of these ideas comes from individual stakeholder interviews and some of them are mentioned several times. There are no clear contradictions or conflicts between sectors for example, between NGOs and industry/investors. Following Alexander (2016), I paid attention to include all the core ideas from stakeholders, and not to include new ideas that were not given by stakeholders. All interview questions used in this chapter can be seen in appendix 2.

5. 3. 2. Organizing phase (Item C of the deductive content analysis, chapter 3)

Future visions' workshop: "elements of sustainability"

Table 10 illustrates the units of analysis (B) grouped into sustainability criteria. As explained in the organizing phase (C) of the deductive content analysis, chapter 3, section 3.2.2.2., the "elements of sustainability" followed three categories: future vision I (reform and regulation ideas), consensus or harmonious ideas and future vision II (equity and radical transformation ideas).

Table 10. Units of analysis (B) from the Future visions workshop organized (C) into criteria of sustainability. The table is built exclusively from the elemnts of sustainbility (words and short phases, appendix 5) put on the wall by stakeholders

Criteria	Future vision I	Consensus or harmonious ideas	Future vision II
Equity & social welfare	Full social and productive inclusion in agriculture		Redistribution of land and wealth
	Access to adequate and healthy food		Equity in distribution
Economic stability & investment	Valorisation of the farmer which adopts sustainable practices - direct/indirect payment for environmental service	Economic incentives for sustainable agriculture (organic, for example)	Change the paradigm of economic development
Culture & tradition preservation	Qualified technical assistance to all, focused on sustainability	Values and preservation of heirloom seeds	Values socio-biodiversity
		Permanent and contextualized technical assistance to family agriculture	Respect for traditional knowledge
Ecosystem services provision & biodiversity conservation		Considers the landscape context	Values the organic matter
		Multi-use of agriculture	
		Conservation of natural resources (forest, water, soils, climate, etc)	
	Better practices on agriculture and cattle ranching (water and soil conservation)	Wide adoption of low carbon emission agriculture	*Agroflorestar* the planet
	Use of better practices on agriculture and cattle ranching	Optimization of land use by avoiding new deforestation	Production diversification (integration, SAF - Agroforestry Systems)
		Supply green belts	Chemical-free system

Use of natural resources & pollution		Expand the adoption of integrated management of pests and diseases (reduction in the use of pesticides)	Diversity of production systems (size, product, scale)
		A preponderance of integrated production systems	Positive energy balance
		Efficient system without waste	Agroforestry belts around cities - local food - urban agriculture
		Highly efficient in the use of natural resources	
		Sustainable technology	
Governance and Policy		Education for sustainability (formal and informal)	Encourage a culture of care
			Change the paradigm of economic development
	Appropriate labelling of GMOs	Enhance sustainability considerations in irrigation law. Improve the legal framework to conserve water resources	Non export-oriented agriculture (positive trade balance)
		Environmental regularization (RL** and APP***)	Control of agriculture by the national State. End of foreign intervention
		Land regularization	Agrochemicals moratorium
		Adapt the legal framework to family farming and extractivism	Do not use genetic modified organisms
		Create laws that encourage sustainable practices and do not bring difficulties or coercion	Encourage people to return and remain in the field

		Reduce the consumption of beef	Consuming products of local biodiversity
		Promote reflection on society on sustainable consumption	Fun
		Education for consumption (e.g. packaging, harvests, local production, reduce meat consumption)	Creative freedom
		Food consumption profile	Food culture "Cult Food"
		Consumers aware of their choices	Direct relation farmer-consumer (e.g. CSA, street market) (beyond the logic of the market)
			Encourage the consumption of local products
			No-anthropocentric nature

Stakeholder interviews

Following the similar approach of the ideas of the workshop in table 10, table 11 illustrates the grouping of the units of analysis into sustainability criteria and visions. The core ideas (units of analysis) were extracted from the questions A.1 to B.3 from the 26 transcribed interviews (see table 10, chapter 5 and appendix 6). As recommended by Alexander (2016), I re-read the whole interviews several times, as well as the new tables grouped by criteria (see examples on table 5, chapter 3), then I re-write and re-organize stakeholders' information into three new categories (table 11). As explained in the organizing phase (C) of the deductive content analysis, chapter 3, section 3.2.2.2., the "elements of sustainability" (units of analysis) were re-organized into three categories: future vision I (reform and regulation ideas), consensus or harmonious ideas and future vision II (equity and radical transformation ideas) and 6 criteria..

Table 11. Units of analysis (B) from the Stakeholder interviews re-organized (C) into criteria of sustainability and future visions

Criteria	Future vision I	Consensus or harmonious ideas	Future vision II
Equity & social welfare	Land reform without limiting size of large farmers	High quality education for population as a central idea and strategy	Land reform limiting size of large farmers
			Restriction to the concentration of land, income and capital
	New balance to equalize public support to all farmers independently of farm size		Public support gradually transferred to sustainable agriculture from small-scale family farmers and medium-scale farmers
	Massive investment to technical assistance based on better management practices		Massive investment to technical assistance based exclusively on sustainable agriculture from small-scale family farmers and medium-scale farmers

		Education for citizenship is central for a transition towards sustainability	
	Market as one of the main strategies for change		Market as an alternative strategy for change
	Balanced governmental support to responsible agribusiness for exportation and sustainable family farmer agriculture		Governmental support exclusively transferred to sustainable production of small-scale family farmers and medium-scale farmers prioritizing domestic market
	Create space, policies and investment to promote local and sustainable agriculture is important, but not excluding public support to conventional and large agriculture		Create space, policies and investment to promote local and sustainable agriculture is essential, excluding public support to conventional and large agriculture
Economic stability & investment	Economic development to induce sustainability to the Brazilian agri-food system		Solidarity economy to induce sustainability to the Brazilian agri-food system
	High priority for investment in big infra-structure to promote agribusiness for exportation (ports, waterways)		Priority for investment in regional and local infra-structure for sustainable food production and consumption
	Public credit to all farmers linked to better management practices		Public credit exclusive to small-scale and medium-scale farmers linked to sustainable agriculture

Culture & tradition preservation	Technological transfer through technical assistance and financial support would bring better life conditions to traditional communities and poor farmers	98	Traditional culture is essential pillar of sustainability. Traditional people and knowledge would be respected and part of the policy framework to promote and achieve sustainability
Ecosystem services maintenance & biodiversity conservation	Based on better management practices		Based on sustainable agriculture
	Conservation of ecosystem services based on adaption of policies and market mechanisms, like payment for ecosystem services		Decentralised and focus on territory policies to ensure variety of products and conservation of ecosystem services
Use of natural resources & pollution	Better management practices as sustainability standard	Technical assistance is the most important strategy	Sustainable agriculture as sustainability standard
	Low to moderate changes on credit policies		Radical changes on credit policies
	Better management practices, control and monitoring of the use of natural resources		Radical improvement on the use of natural resources and animal ethics. Elimination of agrochemicals
	Control, inspection and regularization approached by firm government actions would be a main mechanism of change		Control, inspection and regularization approached by government and a strong society role would be an important mechanism of change
	Controlled use of external subsidies into the agri-food system		Low dependency on external subsidies into the agri-food system

	Certification schemes as an important mechanisms to apply better management practices	99	Farmers and consumers would develop co-responsibility to improve sustainability
Governance	National policies for agri-food system needs several and significant changes towards sustainability		National policies for agri-food system needs several and radical changes towards sustainability
	Support to agribusiness, policy for exportation, use of agrochemicals and GMOs, but improving management practices	Industrial mechanisms to add value to products	Support to agribusiness, policy for exportation reduced and transferred to small-scale family farmers and medium-scale farmer. Eliminate the use of agrochemicals and GMOs
	Premium price and payment for ecosystem services to farmers applying better management practices, and use of certificate schemes		Social and sustainable technologies build in partnership between small-scale family farmers, traditional communities and government agencies and universities
	Strength PLANAPO, agroecology and organic agriculture as a complementary strategy		Strength PLANAPO, agroecology and organic agriculture as main strategy
	Societal awareness is important, but not a central idea to improve sustainability, vision relies mainly on government and institutions for changes		Societal awareness is essential and central idea for the improvement of sustainability. Vision relies mainly on society awareness and action for changes

	Development of co-responsibility towards sustainability is a complementary strategy		Development of co-responsibility towards sustainability is essential and central strategy
	Consumers should be informed by labels and certification schemes		Consumers should be informed by labels and certification schemes, but also being proactive in participatory certification, CSA, street market etc
	Government and market would be the main force to induce changes and develop awareness on society that consequently would pressure government for more improvements		Society would be the main force to induce changes and pressure government for more improvements

5. 3. 3. Reporting the analyzing process and the results (Item D of the deductive content analysis, chapter 3)

Future visions

Several of the stakeholders' ideas were mentioned more frequently and had no contradictory or conflicting ideas. However, this does not mean that all stakeholders agreed or prioritized all of them as the main issues for the Brazilian agri-food system. It means that these ideas do not conflict with other ideas and suit both future visions. As an example, two of the most frequently mentioned ideas were the strategy to boost sustainability through technical assistance to farmers and quality of citizenship education. For instance, fifteen stakeholders cited the word education in several different questions during the interview. One example of a researcher comment is: "A very low quality education is an obstacle to have more critical citizenship in all senses,

social, environmental, etc". Another one from a participant from the industry: "Citizenship, education, to know where it begins the right of the other, the respect for people, for nature. The issue of education should be a priority". Technical assistance and quality of citizenship education are main strategies for both visions, however with different perspectives.

On the other hand, the two future visions were created mainly based on contradictory and conflicting stakeholder opinions about the sustainability of the Brazilian agri-food system, analysed from the core ideas of the future visions workshop and interviews (see table 10 and 11). From some ideas advocating reforms for the Brazilian agri-food system made predominantly by a top down approach, I develope a narrative describing the "In-depth reform vision". From some ideas defending a radical transformation for the Brazilian agri-food system made primarily by a bottom up approach, I develop a narrative describing the "Radical transformation vision". Some conflicting ideas of these visions are for example, the public support of GMOs and conventional agriculture by In-depth reform and the restriction of them by the Radical transformation. The use or not of the GMOs was one of the biggest disagreement of the Future visions workshop. Some stakeholders agreed to include the total ban on the use of GMOs as an essential element of sustainability for the Brazilian agri-food system. Others required the inclusion of GMOs as an element and alternative for sustainability, although with an appropriate management and labelling of the products. At the end of the day, both viewpoints entered as elements of sustainability, however split in two different visons afterwards. On the other hand, some ideas are complementary and could be applied with different perspective, intensity or priority in both visions, as for example the use of international agreements.

One significant difference between stakeholders' ideas that support the creation of two visions is the approach (top down or bottom up) adopted to provide sustainability change. An important example of this difference is the foremost-cited element for change: quality citizenship education. It is a consensus that both formal and informal education for citizenship is the central element to provide changes towards sustainability, however there are two different perspectives on how to improve the educational system and generate the desired results. Some stakeholders believe that it is the government's responsibility to improve the educational system and generate conditions for change. A top down approach to improve formal education in the long

term would lead to better educated citizens that would contribute to the transformation of the agio-food system. For instance: "Education for citizenship. We do not educate citizens. We graduate physicians, mathematicians. The government, the Ministry of Education has to think that they need to graduate people, Brazilian citizens, and then let's change the university programs… Let's start from politics, more human thoughts, from the top of the politics" (Consultant). "It had to come from the change of the country's educational system. The teaching guidelines are defined at the federal level, the Executive through the Legislative should make the changes, and the implementation at the municipal and state level" (Researcher). Others consider that governments in general are corrupt and have vested interests in the current unsustainable system. They are the biggest barrier to the improvement of quality in education and sustainability. From this perspective, an informal education and social awareness coming from civil society and social movements would generate informal educated citizens. They would act for and pressure the government to improve formal education and sustainability. "I believe that the name of this is education. Which education do we want? We have to practice democracy. The consumer has to know how to distinguish and value these things, otherwise there is no change" (Consultant). "It is a lack of systemic education, participatory, adaptive... a new posture from all of agents of the system, farmer, researcher, agrarian technician, because there are opportunities in each one of these sub-systems" (Researcher). "We have to build it from social routes, democracy, a change on the vision, you know… education, 'conscientizacao' (critical consciousness), Brazilian society awareness. Everybody who produces counterculture, teacher, artist, NGOs, people questioning the dominant regime (NGO).The Radical transformation vision shares some similar elements with food sovereignty discourse (e.g. redistribution of land and wealth, table 10). On the other hand, In-depth reform includes some elements of food security discourse (e.g. access to adequate food, table 10). According to Windfuhr (2005: 15) "while food security is more of technical concept, and the right to food a legal one, food sovereignty is essentially a political concept." Food sovereignty goes beyond the definition of food security (see chapter 2), i.e., the right for food. Following Via Campesina (2006), food sovereignty is a precondition for genuine food security; it is the right of each country to maintain and develop its capacity to produce its own basic foods, whilst respecting cultural and productive diversity. The International Planning Committee for Food Sovereignty (IPC) prioritizes four pillars: the right to food; access to productive

resources; mainstreaming of agroecological production; trade and local markets (IPC, 2006). According to WTO's glossary (2017), food security "lies not only in the local production of food, but in a country's ability to finance imports of food through exports of other goods". Radical transformation vision ideas (e.g..: less international influence, end priorities for exportation) are more aligned to IPC ideas. For instance some quotes from the interviews: "The economic system needs to improve from a vision of profit to a vision of solidarity economy, land reform, land distribution is central, reduce the political and economic power of big multinationals" (Government). "These big multinationals are barriers for the country" (Consultant). Our bottleneck is not technological, it is economical politics... it is the unequal appropriation of land, natural resources, regional inequalities, this is the problem" (Government). "Highly mechanized agriculture is one of the very serious problems, for one calorie of soy it is spent 5 calories of petroleum, in a technology that cause dependency" (Government). "The technological challenges are minimum" (NGO). The In-depth reform vision ideas centre on technological innovations for a sustainable development of agribusiness and market development (national and international) to guarantee food security, more aligned to the WTO's propositions. For instance, some quotes from the interviews: "Access new market, other markets, it would be very good for Brazil, international and domestic market" (Industry). "Technological changes that allows an intensification of the cattle ranching, that is a key point for Brazil. I am optimistic if technology is combined with regulations, inducted by institutional mechanisms. The creator of public policies has a huge importance in this technology issue" (Researcher). "Better inspection of agribusiness, especially about the use of agrochemicals and natural resources… payment of environmental services" (Researcher). "We need more efficient machines, more efficient technologies, which use less energy, alternative fuels, biodiesel" (Industry).Below, I present the two narratives (In-depth reform and Radical transformation) of a desirable future for a sustainable Brazilian agri-food system based on stakeholders' ideas and perspectives. See appendix 7 for detailed narratives of the future visions specified per criteria.

Future vision I – In-depth reform

The stakeholders' ideas that form the In-depth reform vision advocate adequacy, rearrangement, adjustment and/or improvement of the Brazilian agri-food system.

According to some stakeholders, the specific national policy is missing focus, vision and more objective strategic planning "It is far from enough and it is far from be efficient as well. I think that it doesn't accomplish with its visions (Consultant). "There are big deficiencies in the regulation and implementation, and there is no prioritization of the government for these questions" (Researcher). "I think that the public policies can help, but today they are very wrong" (Government). "In terms of national policy is completely inadequate… Each one is running a different objective (talking about MAPA, MDA and MMA) (ONG). "In the national point of view there are still deficiencies. There is a lack of focus or vision or a more objective strategic planning" (Industry). "The big (farmer) has a lot to improve, even remaining conventional and increasing the productivity" (Government)

Consequently, several significant changes to national policy would be required to achieve improvements. However, this vision is less critical of the current agri-food system than the Radical transformation one. International agreements are very important in this process because they open space for sustainability projects into the institutions. "Yes, they show guidelines to be followed. They are a baseline for national policy" (researcher). I think that these agreements are always pedagogical… they have a lot of difficult to become effective, but they work as a pedagogical process" (ONG). "They are important, but not effective… they are voluntary goals as well, but I think that they are important as reference" (Government). The ideas of In-depth reform are aligned with the concept of food security, i.e., the population's physical and economic access to safe and nutritious food. The FAO, UN and WTO adopt the concept in their policies. Government and the market would be the main forces promoting sustainability in the system, which is more inclined to follow a top down approach for implementation. The vision is driven by economic development, increased competitiveness of the Brazilian agri-food system and access to domestic and international markets. One of its main strategies is the transfer of technologies to all farmers through massive investment in technical assistance based on better management practices to improve sustainability performance.

"We have technology to produce, yes, it can be organic or conventional, but this information is not delivered, this knowledge is not delivered to the small farmer or medium farmer" (Farmer). "We need more efficient machines, more efficient technologies that uses less energy, which uses alternative fuel, biofuel" (Industry).

These strategies would reach a balance between public support for conventional agriculture (including monocultures, agrochemicals, GMOs, export-oriented agriculture) and sustainable agriculture (organic, agroforestry, agroecology). Technical assistance and public credit would be part of the same package and would be addressed to all farmers independent of their size, however with the condition of applying better management practices as standard for sustainability. "Yes, credit for both large and small farmer" (Industry). "To make an equivalence from the rigorous Brazilian legislation (environmental) with the legislation of other countries, or scaling up payment of environmental services, carbon credit" (Industry). "The issue of credit is well solved in this country, technical assistance, this is critical in this country" (Industry). Investments in infrastructure are essential to facilitate the flow of products, mainly big ports, railways and waterways to promote agribusiness for export. "Gradually transfer the agricultural and cattle ranching production from roads to railways and waterways" (Industry).

Future vision II – Radical transformation

The stakeholders' ideas that form the radical transformation vision advocate huge changes to the Brazilian agri-food system. The same arguments were made, that the national policy is missing focus, vision and more objective strategic planning for sustainability and is valid for this vision. However, radical changes would be required for the achievements of real improvements. "The positive trade balance? While this would be the goal, there is no sustainability. I do not think that this is the way, only crumbs, for sustainability, family agriculture, 'quilombolas', and indigenous peoples. We need a decent land reform" (Farmer). "Do they create a call for agroecology? Agroecology had to be the baseline for all technical assistance! Contradictory policies, one to incentivise herbicide, to remove tax from herbicide, and now we have a national programme to reduce the use of agrochemicals. They are completely antagonistic" (Government). No... this policy is a perverse subsidy... Government is subsiding all unequalities, all the environmental cost" (NGO).The vision goes beyond the sustainability aims of international agreements. They are considered important because they open space for sustainability projects into the institutions. However, it is essential to change the implementation mechanisms of those agreements in order to

improve empowerment or linkages to the population. "Yes, they are important, but they are not the axis, the axis is local, the national policies" (Researcher). "They are irrelevant to 98% of the population that do not know why do they exist and the national legislation does not follow them" (Government). "They have never arrived to me, then I don't believe that they are not effective" (Consultant). The ideas of the radical transformation vision are aligned with the concept of food sovereignty, i.e. the true right to food and to produce food (Windfuhr and Jonsen; 2005). The concept was created in 1996 and is defended by NGOs and social movements, such as Via Campesina. Therefore, society is the main force promoting and pressuring government to generate sustainability into the system, in a bottom up approach. It would be necessary to make solid improvements towards solidarity economy, sustainable production and consumption, based principally on citizens, but also government taken responsibility for change "We have to build it from social routes, democracy, change on the vision" (NGO). As for In-depth vision, massive investment in technical assistance is one of the main strategies. However, technical assistance would be re-structured based on sustainable agriculture, with the participation of traditional people and their knowledge, as well as small-scale family farmers. "We need an autonomous technology which increase the efficiency of the work, that facilitate the life of human beings, but it is not dependent of energy, material, aluminium, etc (Government). "We need to change the conception for the development of these technologies. Around 70% of the developed technologies does not reach the final beneficiary because they are nort suitable, because there were not developed in partnership (meaning with small farmers, traditional communities). The resources to develop these technologies suitable to conventional agriculture is much higher than the resources intended for these technologies… more social technology" (Government). Public support and credit would be directed exclusively to small-scale family farmers, traditional communities and medium-scale farmers, emphasizing local sustainable production and consumption and the domestic market. "The credit should be totally restructured and much more directed to small scale family farmer" (Researcher). "Turn more expensive the credit for non-sustainable agriculture" (ONG). There would be an elimination of conventional agriculture, agrochemicals and GMOs (see table 10). Investment in large infrastructure is important, but not a priority. The focus would be on regional and local infrastructure to benefit local communities. "We need more infra-structure at rural

areas and schools" (Industry). We need to strength the alternative system with structural policies and technology… strength the education in rural areas" (NGO).

Detailed narratives created based in the transcription of the interviews

In order to go deeper into the understanding of the contrasting and conflicting ideas to build the two future visions and to densely explore the meaning of stakeholder feedback (as suggested by Alexander 2016), I develop a more detailed narratives based on the transcription of all interviews (appendix 6). For each interview, I highlight parts of the transcribed text (words, sentences) that represented the core idea of each question/issue (A1. Problem, A2. Solution, A3a. Institutional sustainability goals, A3b. Personal goals, B1. Institutional compliance to sustainability, B2. International agreements, B3. National policy). Then, I include the core ideas from each stakeholder in the same Excel spreadsheet per question (A1, A2…). For each question (placed in separate spreadsheets), I group the core ideas (units of analysis) from stakeholder interviews that were similar or closely related in the same row. For example, the narrative of social inequality (appendix 6, item A1.1) was built from the following grouped core ideas given by stakeholders: unequal system; income, land and capital concentration; unequal access to the means of production; violence and murders; formation of slums in cities etc. Another example of a group of units of analysis is the problem of the hegemony of commodification, exportation and low added value system (A1.8) for which the core ideas are: commodification, hegemony of a model for exportation with low added value to agricultural products, disparity between the benefits and allowances received by the family agriculture versus agribusiness, etc. For both examples of narratives, different stakeholders cited some of these core ideas several times. As recommended by Alexander (2016), I re-read the whole interviews several times in order to write the narratives. The narratives (meta-text, according to Moraes and Galiazzi 2011) includes the words and expressions given by stakeholders, not adding new ideas or meanings into the text (appendix 6).

Detailed perspective of the future visions

With the same objective of deepening understanding and densely explore the meaning of stakeholders feedback (as recommended by Alexander 2016), I develop detailed

narratives for both future visions (appendix 7). In this case, revisiting several times the interviews (Alexander, 2016), I also use the results from the future visions workshop (table 10) and the detailed narratives produced for the interviews (appendix 6).

. The narrative construction (meta-text, according Moraes and Galiazzi 2011) of the future visions followed the structure (criteria) developed for the hierarchical indicator framework (figure 4, chapter 3) to conceptualize and describe the sustainability of agri-food systems. The use of this framework in all chapters of this research gives a reference that permits an analysis and comparison of distinct discourses in relation to the specific perspective of sustainability adopted by this research (see the perspective in chapter 3). The criteria group from the indicator framework was the main mechanism of comparison and analysis of the stakeholder's perspective. The narratives includes the words and expressions given by stakeholders, not adding new ideas or meanings into the text (appendix 7).

5. 4. Discussion

The aim of this chapter is to create future visions for a sustainable Brazilian agri-food system by 2030. I create two future visions mainly based on stakeholders' contrasting and conflicting perspectives about the theme. However, there are also similarities and complementarities between the visions. I discuss the transition to implement each vision, strategies, feasibility and trends in chapter 6.

In general, stakeholders' opinions about the sustainability of the Brazilian agri-food system corroborate with the results found in chapter 4 based on indicators of sustainability. Stakeholders mentioned the main challenges and problems, such as environmental degradation, impacts on ecosystem service provision, negative impacts on traditional communities, an emphasis on social inequality, etc. The most notable exception was the absence of comments about gender inequality. On the other hand, stakeholders mentioned two very relevant points not assessed by the hierarchical indicator framework in chapter 4; governance and power (see analysis of these two elements in chapters 6 and 7). I highlight the most relevant information per criteria below.

Equity & social welfare

One significant difference between the visions is the approach to improve equity and social welfare (criterion of sustainability in chapter 4) in the Brazilian agri-food system. The ideas from the In-depth reform vision suggest / propose improvements in access to adequate and healthy food, while the Radical transformation vision adds to it the need to distribute land and income more equitably (see tables 10 and 11). According to the literature review (chapter 2) and the results from chapter 4, Brazil is a very unequal country. It is possible that only a strong redistribution of land and income, as proposed by the Radical transformation vision, could bring a real improvement in equity and social welfare. However, as mentioned by several stakeholders, some powerful forces from the agribusiness sector like BBB (cattle, bible and bullet, see item B3, appendix 6) are strong opponents of this transition. As stated by Fuchs et al. (2015), power is a constant missing element in the sustainability agenda. The concentration of power is one of the principal impediments to sustainability in the Brazilian agri-food system, at least with respect to equity and social welfare aspects (see chapters 6, 7 and 8). Nevertheless, because of the concentration of power, it is unlikely that there will be limits to the size of farms or income in the short term, as defended by Radical transformation vision. Consequently, for this criterion, the ideas of the Radical transformation visions are less likely to happen than the improvement of access to adequate and healthy food from In-depth reform. In both visions, what is really missing is a perspective of gender inequality, as no stakeholder mentioned this as a problem or solution for the Brazilian agri-food system (15 women out of 31 participants, took part of the workshop and/or interview). However, the participation of women in the agricultural workforce and in positions of power in politics are big challenges to be overcome in Brazil (see chapter 4).

Economic stability & investment

Agricultural commodities for export have been very important for the Brazilian economy and balance of trade (see chapters 2 and 4). Agriculture reached 46.2% of Brazilian exports in 2015 (MAPA, 2016). However, stakeholders have conflicting opinions about whether the outcomes of agribusiness really benefit the entire Brazilian society or not. These are among the most contrasting ideas between the visions.

Strong investments in agribusiness have concentrated agricultural production in a few commodities. Soybean, maize and sugar cane cover about 72% of the total area harvested in 2011 in Brazil (FAOStat, 2017). Analysing stakeholders' feedback, I highlight three main risks that the intense focus on a few commodities by agribusiness practitioners and government pose to Brazil. First, the loss of traditional communities and small-scale family farmer's ability to keep socio-biodiversity and knowledge of means of production, important components to overcome the effects of environmental changes and guarantee a good quality of life for those populations (see item A1.4, appendix 6). Second, the harmful environmental impact caused by the intensive use of natural resources and agrochemicals by these commodities (see item A1.6, appendix 6). Third, economic dependence on a few commodities with low added value, highly dependent on external inputs, with a very unstable price established internationally (see item A1.8, appendix 6, chapters 2 and 4).

It is possible and necessary (see chapter 6) to improve the sustainability performance of large conventional agriculture. However, this is unlikely to take place due to the powerful alliance of agribusiness industry and government actors, which presents barrier to significant change in this sector, especially in human wellbeing aspects. In this context, the In-depth reform idea that economic development with firm government control would be efficient to induce sustainability in the Brazilian agri-food system is questionable (see item A2.6, appendix 6). Government control is not enough to guarantee broad sustainability (human wellbeing, food security/sovereignty, environmental quality) because of corruption, economic interests, maintenance of privileges, concentration of power and wealth, etc. that characterise the current system (see item A1.10, appendix 6). Several stakeholders mentioned that government is the main barrier to a transition towards sustainability. In this context, according to some people interviewed, pressure on the government from responsible market and multi-stakeholder initiatives (e.g. Coalizao Brazil, Clima, Agricultura e Floresta) can be an interesting alternative to bring about change.

According to chapter 4, the current Brazilian agri-food system needs huge changes to achieve sustainability. Ideas from Radical transformation follow the same pattern, proposing that sustainability is not possible within the current model of large conventional agriculture (see item A1.10, appendix 6). Some stakeholders associate well-being more with access to quality food, free time and community development

than with economic benefits from agribusiness exports. Probably, changing all food and biofuel production towards small and local sustainable agriculture, as advocated in Radical transformation, would bring big social and environmental gains (see table 10 and item A1.4, appendix 6). However, the challenge to make these changes and establish a new solidarity economy based on society co-responsibility and participation is colossal. There are strong difficulties and uncertainties in this pathway (see chapter 6). It is naive, at least for the medium-scale term, to believe in a radical solution that would end agricultural production for exports to eliminate its negative impacts. Even if small-scale family farmers can practice more sustainable agriculture than larger farms (MDA, 2009), generally they are also unsustainable. Results from chapter 4 show that the official area with sustainable agriculture in Brazil is insignificant. It means that all farmers need to improve sustainability. In addition, a radical change would be too risky for the economy, weakening the national balance of trade. A big effort is needed to open and keep new markets for more sustainable products other than the current commodities. Three commodities cover 72% of harvested area because of government incentives; other incentives for small-scale family farmers and medium-scale farmers should be opened. However, some uncertainties have to be previously explored. Can small-scale family farmers and medium-scale farmers supply the demand of commodities for export and do it more sustainably? Can the domestic market support the economy in substitution of monoculture for exportation? Can Brazil create domestic and external demand for a diversified range of local biodiversity goods produced sustainably? If the answer is yes for all these questions, it is likely that the sustainability of the Brazilian agri-food system could be improved significantly.

At least medium term (also as a transition), it seems more feasible to establish a coexistence between large conventional agriculture and sustainable agriculture from small-scale family farmers and traditional communities. Therefore, an intermediate pathway between the two visions would be more easily achievable. I present alternative pathways and policy prescriptions in chapter 7.

How future investments would be made are also a consequence of the success of these two different visions. As public resources are scarce and the agribusiness industry has an influence on spending it, it is most likely that spending is directed towards big

infrastructure to support commodity exports (ports, e.g.) rather than infrastructure for community development (public storage, e.g.).

Culture & tradition preservation

How to guarantee human wellbeing, specifically good quality of life for traditional communities? The solutions for the In-depth reform vision are more interventionist, i.e., credit, qualified technical assistance, and transfer of technology would provide the conditions for traditional communities to achieve development (see appendix 7). Conversely, according to the Radical transformation, traditional communities are co-participants of development. The Radical transformation vision considers that preserving values from socio-biodiversity and traditional knowledge are crucial for sustainability (see appendix 7). As shown in chapter 4, agriculture has been the main cause of displacement of traditional communities and conversion of native forests (see chapter 2 and 4). Sociocultural diversity loss, like linguistic diversity, also has an indirect negative impact on biodiversity, since traditional communities have conserved the genetic diversity of cultivated plants (UICN, 2011). However, the aim of sustainability should not be only to use traditional communities to protect biodiversity. A broad meaning of sustainability (advocated in this research and by food sovereignty discourse) including wellbeing for all should empower traditional communities to make their own decisions, choices of technology and life style.

Ecosystem services provision & biodiversity conservation

As expected, all the interviewed respondents recognized the importance of conserving biodiversity and maintaining ecosystem services. Government control, which is more related to In-depth reform ideas (see table 10), can achieve a reduction of deforestation in the Amazon (see chapter 2 and 4). Even if deforestation is not under control, it shows that this type of top down approach can produce good results. However, it is also true that civil society (Radical transformation ideas, see item A2.8, appendix 6) keeps pressuring government and market to avoid deforestation and this pressure is a cause for government action. There are several projects from civil society on the

ground contributing to reduce deforestation as well (e.g. Coalizao Brazil, Clima, Agricultura e Floresta). Therefore, both strategies are essential and complementary.

Use of natural resources & pollution

According to the In-depth reform ideas, sustainable use of natural resources would be achieved by using better management practices, while Radical transformation ideas rely on the exclusive establishment of sustainable agriculture (see table 10 and item A2.5, B3, appendix 6). However, their effectiveness depends on how both ideas would be controlled, monitored, and most importantly how they would frame sustainability. For example, principles and criteria are very weak for many certification schemes, an important measure for In-depth (see chapter 2). The large variety of certifications and their complexity make it almost impossible for consumers to comprehend which ones have a higher or more robust quality standard. For sustainable agriculture, widely defended by Radical transformation, there are still uncertainties about the efficacy of implementation of its main instrument, PLANAPO (National Plan for Agroecology and Organic Production), or even guarantee that it will be implemented. For both visions, the key factor for the success of the mechanisms is the rigor and investment in their implementation. For instance, according to some stakeholders, the use of sustainable agriculture or better management practices should be a condition of access to rural credit, an important instrument for both visions (see item A2.5, B3, appendix 6).

There is also a recurrent concern among stakeholders about taking into account multi-use of agriculture and landscape context for the sustainability of agri-food system (see item A1.5, A2.3, A2.7a, appendix 6). These elements refer to a significant change in the landscape dynamic with the insertion of big areas of monoculture, which carries in loss of socio biodiversity and provision of ecosystem services, as demonstrated in chapter 4. This concern is very pertinent, because the related policies have not been properly implemented as well. The implementation of such policies would suit both visions (see chapter 6).

Governance

The ideas that form the In-depth reform vision are critical to the current Brazilian agri-food system. However, they have some similarities with the perspectives of MAPA (2015a), OECD (2015) and EMBRAPA (2014) which rely on the reform and improvement of policies based on economic growth, market and technology development as the main measures to bring about sustainability(see table 10 and item A1.8, A2.7, B3, appendix 6). Thus, ideas from In-depth reform vision tend to be more positive about the current sustainability of the Brazilian agri-food system, even if these ideas highlight need for significant improvements. Seemingly, according to this view, advances could be reached with the adjustment of national policy to align with the goals and agenda adopted by the international agreements, specifically the SDGs and Aichi targets. Both the In-depth reform ideas and international agreements are aligned to the concept of food security, the access of quality and affordable food and health, which is usually the approach adopted by international agreements and international agencies like FAO, UN, WTO.

Radical transformation ideas promote a broader and more inclusive perspective of sustainability as supported by (Binder et al., 2010) (see table 10 and item A1.8, A2.7, A2.9, B3, appendix 6). Similarly, to Padua (2004) they are very critical of the current system, considering the exorbitant focus on monoculture for export one of the main sources of unsustainability. Changes advocated by Radical transformation ideas are aligned with food sovereignty, where the democratic right of peoples and sovereign states to determine their own agricultural and food policies is guaranteed, as well the right to produce and access the means to produce food (Via Campesina, 2006). "Not only think about the concept of food security, but food sovereignty, agriculture sovereignty" (Government interviewee). According to Lee (2007), the concept was developed by Via Campesina as a counterpoint to the world trading system through AoA (Agreement on Agriculture from World Trade Organization). For this reason, the Radical transformation vision is a bottom up approach and depends much more on changes coming from societal behaviour, such as through changes in consumption, individual action and co-responsibility for change. It has some alignment with SSFFAD perspective in relation to the priority of policies to benefit small-scale family farmers. In contrast to In-depth reform, Radical transformation ideas go beyond sustainability goals and agendas of international agreements like the SDGs and Aichi

targets, adding to them a stronger perspective of social justice rather than social inclusion and access to adequate resources.

This chapter aimed to create future visions for the sustainability of the agri-food system according to a group of stakeholders working in this area in Brazil. This chapter does not explore trends in depth, or the viability to implement the future visions. The visions and their insights are essential to create the next step (chapter 6), transition pathways to achieve sustainability. chapter 6 discusses trends in the Brazilian agri-food system and the viability of each vision, as well as their policies, measures and strategies of implementation. chapter 7 provides alternatives and policy prescriptions for a sustainable transition pathway for the Brazilian agri-food system, combining the complementarity and feasibility of both visions.

5. 5. Conclusion

The implementation of both visions have immense challenges. In-depth reform vision is more likely implementable. However, if implemented, the In-depth reform vision would be only partially effective, because its sustainability is weaker than the Radical transformation one. In addition, In-depth reform is based on a top down approach. According to some stakeholders, this makes its implementation more difficult, since government is not trustworthy, due to corruption and vested economic interests.

Radical transformation vision is very unlikely to be implemented. However, the strong society participation in this vision (bottom up approach) could generate more solid and durable changes towards sustainability. The huge challenge is how current social movements can mobilize society towards these changes.

The aim of chapter 6 is to explore possibilities to create a transition pathway for both visions.

6

Transition pathways for a sustainable Brazilian agri-food system

6. 1. Preamble

This chapter describes the transition pathways to achieve sustainability in the Brazilian agri-food system based on each one of the two future visions created outlined in chapter 5 (In-depth reform and radical transformation), as well as the viability of their implementation. The two transition pathways reproduce the insights acquired from stakeholders working with the theme in Brazil, based on 26 interviews and two workshops (see methodology in chapter 3). The viability of implementation considers stakeholders' opinions with the support of results from chapter 4, which assess the sustainability of the Brazilian agri-food system, and by the literature review findings in chapter 2. The complementarities between the two future visions, general policy prescriptions and my suggestions for the transition pathways to achieve sustainability in the Brazilian agri-food system are presented in chapter 7.

6. 2. Methodology implementation: Backcasting analysis

The aim of the backcasting analysis, the third step of the backcasting approach (see figure 1, chapter 3), is to build transition pathways for the sustainability of the two future visions of the Brazilian agri-food system. The methodology is described in section 3. 2. 3 of the chapter 3 and the results presented in this chapter. I use inductive content analysis as a support to select, organize, report and analyse the data from the feedback of stakeholders in order to perform the backcasting analysis (see the stages and results below).

6 .3. Results

In this chapter, I identify transition pathways for the sustainability of the two future visions (chapter 5) for the Brazilian agri-food system. As mentioned in the chapter 3, I use participatory backcasting approach with the support of content analysis. Following the inductive content analysis (see section 3.2.3, chapter 3). Firstly, I explain the item B. Selecting the unit of analysis (6.3.1, this chapter) from the outcomes of the future visions workshop, interviews and transition pathways workshop. Secondly, I explain the item C. Organizing phase (6.3.2, this chapter). Finally, I describe the item D. Reporting the analysing process and the results (6.3.3, this chapter) generated to build transition pathways for both visions of the Brazilian agri-food system.

6. 3. 1. Selecting the unit of analysis (item B of the inductive content analysis, section 3. 2. 3, chapter 3)

As suggested by Alexander (2016) and Burnard, (1991), I select as units of analysis important portions (word or short phrase) of raw text and quotes from the future visions' workshop, interviews and transition pathways workshop.

Future visions' workshop

With the exception of the first two questions (see table 2, chapter 3) of the Future visions workshop, I use all remaining ones to select the units of analysis for the inductive content analysis to build transitions pathways for the Brazilian agri-food system. These questions follow the backcasting analysis (Quist, 2013) looking "backward from the desired future situation, evolving around the questions 'WHAT changes are needed to bring about the vision?', 'HOW can the changes be brought about?', and 'WHO could or should contribute or oppose realizing the vision and what activities should they do?"

Stakeholders interviews

The units of analyses are core ideas representing the answers for all question/issue (see table 3, chapter 3). Each one of these ideas comes from individual stakeholder interviews and some of them are mentioned several times. Following Alexander

(2016), I pay attention to include all the core ideas from stakeholders. All interview questions can be seen in appendix 2.

Transition pathways workshop

The units of analysis of the Transition pathways workshop include the new insights given by participants during the workshop about all information compiled and organized from the Future visions workshop and interviews.

6. 3. 2. Organizing phase (item C of the inductive content analysis, section 3. 2. 3, chapter 3)

The result of the organizing phase is the outcome of Quist's, (2013) what-how-who analysis, the required changes, measures and stakeholder involvement for the improvement of the sustainability of the Brazilian agri-food system (see methodology in the inductive content analysis, organizing phase, section 3. 2. 3, chapter 3). In total, I identify and group 159 measures into 12 strategies:

Better management practices (15)

Promote sustainable technology (12)

Policies for sustainability (40)

Effective government control (10)

Financing and credit (15)

Social governance (6)

Technical assistance (6)

Local, sustainable and decentralized agriculture (6)

Communication and campaign (3)

Education, research and university extension (13)

Co-responsibility and sustainable consumption (15)

Society mobilization (18)

The classification of measures into strategies for the In-depth reform vision can be seen in appendix 11 (presented as figure) and 12 (presented as table), and for the Radical transformation vision in appendix 13 (figure) and 14 (table). This section presents the compilation and categorization of measures into 12 strategies. In section 6. 3. 3, development of transition pathways, I discuss the main strategies and measures for each vision, as well as their importance and role for the visions.

6. 3. 3. Reporting the analysing process and the results (Item D of the inductive content analysis, section 3. 2. 3, chapter 3)

According to the methodology explained in the section 3. 2. 3, item D of the inductive content analysis, chapter 3, firstly I analyse and discuss the main strategies and measures of both visions to build transition pathways for the sustainability of the agri-food system. In the last section, the scenario sustainability analysis, I analyse the scenario for the implementation of each vision.

Development of transition pathways for the sustainability of the Brazilian agri-food system

I create the transition pathways interpreting which and how stakeholders' measures and solutions to improve the sustainability of the agri-food system would apply to each future vision. All measures are made of units of analysis coming from stakeholders' feedback. As mentioned in the section 6.3.2, all measures, and consequently all strategies are made exclusively and represent stakeholders' ideas and insights (as shown in table 10, 11, 12, 14 and appendices 6 and 7). I use narratives (as recommended by Raskin, 2010, Voorn, 2012, Eames & Dixon, 2012) to define the key strategies to implement the vision, the most important measures for each strategy and the main interactions between the most relevant strategies and measures. As mentioned in the EU, (2011) report, the use of narratives enrich the future analysis. According to Karl Weick 1995, "the social world does not simply appear to people but is continuously constructed through labels and narratives". Then, a qualitative scenario can be maiden by a narrative and describe the future using words and visual symbols (Miola, 2008). The use of unconventional narratives of global development expands

the aperture for scanning possible futures (Raskin, 2010). The narratives have the intention to convey the essence of these futures, however they provide considerable interpretive flexibility (Eames & Dixon, 2012).

In-depth reform vision

Here I describe the transition pathways for the sustainability of the Brazilian agri-food system by the implementation of the In-depth reform vision (see comparison and differences between the two visions in table 10 and 11, chapter 5). The main mechanism to induce and generate change is the transfer of technologies to all farmers through massive investment in ***technical assistance***. The main sustainability outcomes for this vision rely on the improvement of the entire supply chain of conventional and ***sustainable agriculture*** by the adoption of ***better management practices*** by all farmers. The measures for the implementation of the In-depth reform vision follow a top down approach. The two catalyst points and central strategies to promote sustainability into the Brazilian agri-food system are government based, i.e., ***effective government control*** and ***public policies for sustainability*** (figure 6). Government is a key element in this vision because several stakeholders consider it to have biggest responsibility and to be able to generate the changes needed to achieve sustainability.

All these attributes presented for the sustainability transition towards an In-depth reform vision coincide with the concept of weak ecological modernization pathway develop by Marsden et al. (2013). A transition to a weak ecological modernization prevails if the agri-food regime maintains the dominant frameworks and provides a marginal role for the new niche players and the development of products/process centres in technological and best practice means. Beyond that, the dominant agri-food regime uses a technologically driven model ("sustainable intensification") to absorb the new landscapes and political pressure, liberalizes market, intensifies bureaucratic control and retains food as a commodity.

In figure 6 and 7, the circles represent the strategies. The arrows show the relationship of dependence between strategies. The size of the circle indicates the importance of the strategy. The blue circles are the most important and the catalyst points of the pathway. The black circles are intermediate strategies generated by the catalyst ones.

The purple circles are the main mechanism of change. The green circles are the final strategies and the outcome points of the In-depth vision.
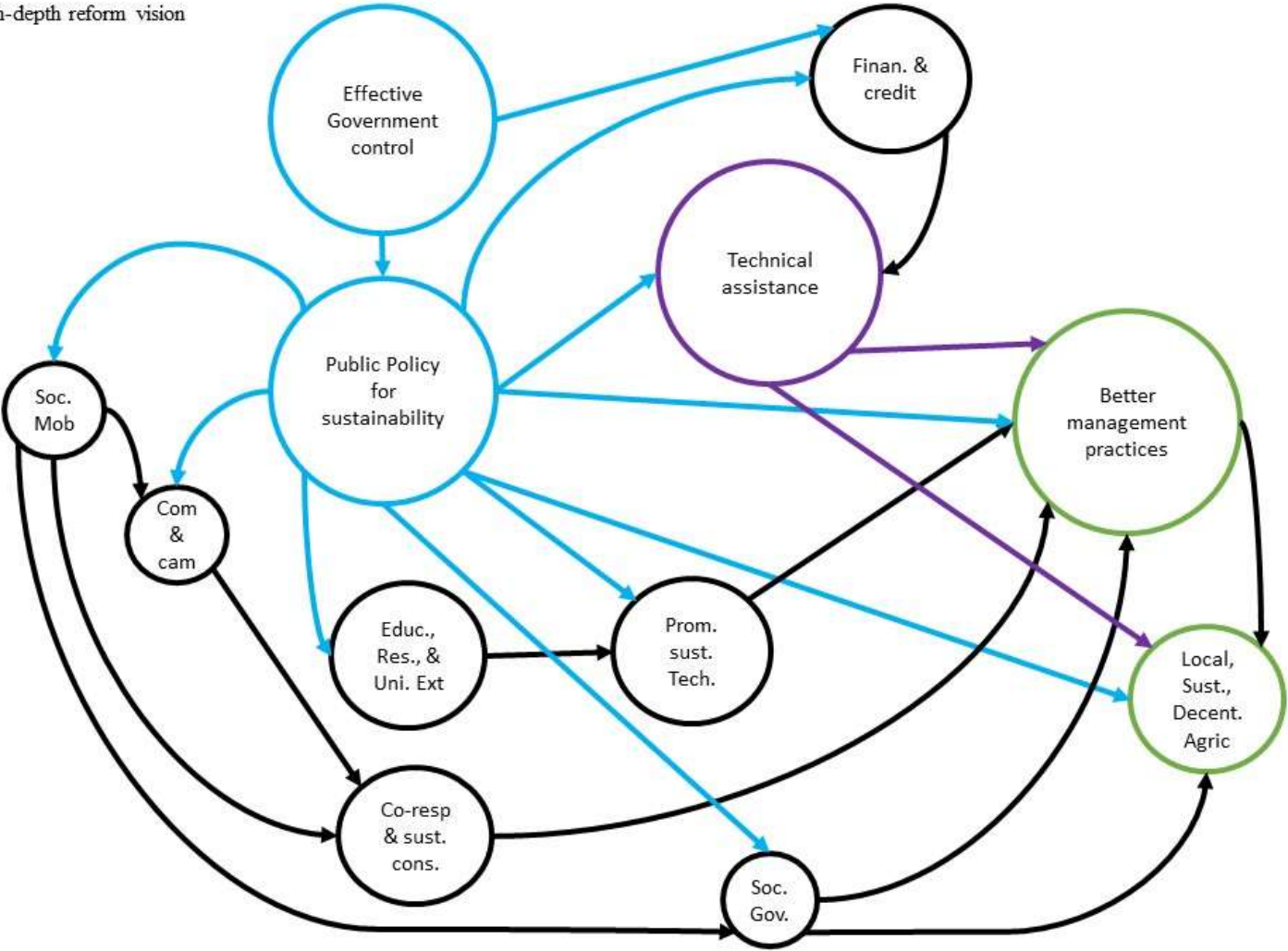
Figure 6. In-depth reform vision diagram

The main measures (darker green squares in the appendices 11 and 12) that I use to create the narrative for the implementation of the In-depth reform vision are concentrated in the following strategies:

The **effective government control** of agri-food system dynamics is a central strategy for the implementation of the vision. Almost all measures of this strategy represent core ideas of the vision (dark green in appendix 11). The measures of this strategy focus on environmental (especially the use of agrochemicals and natural resources) and land tenure regulation (appendices 11 and 12). However, there is no priority to control the concentration of power produced by the market (conflict idea). On the contrary, incentives for the development and performance of the market is one of the most important approaches for the success of the vision.

Government also has a prominent role in the creation of **public policies to promote sustainability**. The challenge is to subordinate all public policies under the criteria of sustainability. Thus, it is essential that the executive and legislative governments commit to adapt public policies to promote sustainable development, taking international agreements (e.g. SDGs and Aichi targets) as a guide for sustainability. An important aim is ensuring access of adequate food for all. Three groups integrate the most relevant ideas of measures in this strategy: investment in infrastructure, territory planning and development of markets. The first group relies on the provision of new investments to expand the transportation network of railways and waterways linked with consistent sustainability criteria, since the main obstacle for the development of the Brazilian agri-food system is the poor infrastructure for the flow of agriculture production. Second, the Brazilian government has to reinforce policies regarding the management of territory using and improving already existing policies and laws of Brazilian cities and urban planning mechanisms (e. g. ZEE – Ecological Economic Zoning, basin committees, law of cities, master plans). The third group of measures supports economic incentives for sustainability such as tax reductions for sustainable production, the creation of mechanisms to fund the restoration of degraded areas and leverage payments for ecosystem services, carbon credits and green bonds. In general, policies treat farmers equally, not providing privileges or strong subsidies to small-scale family farmers or traditional communities. Land reform and policies for

the return of the population to the rural areas are not a priority, and there are no restrictions to the size of rural properties.

The specific strategy for ***financing and credit for sustainability*** aims to guarantee credit and financial incentives fairly to all farmers, using instruments like PPA (Multi-Year Agricultural Plan) and SAFRA (Harvest) Plan to induce sustainable production by the adoption of ***better management practices***. Specific conditions for financing and credit to small-scale family farmers or traditional communities, where special rates of interest and terms of payment can exist, however they are not subsidised as heavily as the Radical transformation vision. Credit offered depends on compliance with ABC (Low carbon agriculture) plan and other sustainability criteria. One of the steps for the success of the strategy is to develop decision-making mechanisms based on sustainability criteria to support the decisions of funders about financing. Accountability of social and environmental externalities and costs is not a priority and all financial and credit benefits reaches both conventional and sustainable agriculture.

Technical assistance is a key strategy for both visions. According to several stakeholders, it is an obstacle to sustainability change. Therefore, EMATER (State enterprise of technical assistance and rural extension) should receive massive investments from the government to implement ***better management practices*** and disseminate and ensure farmer access to sustainable technologies. The first step is to consolidate ANATER (National agency of technical assistance and rural extension), the national agency responsible for managing and fostering ***technical assistance*** at federal, state and municipal levels through several EMATER units scattered around Brazil. The In-depth reform focuses on the transfer of technology based on ***better management practices*** for both conventional and sustainable agriculture.

Better management practices is more than a strategy with specific measures; it is also the main output and key reference of the vision for the improvement of the Brazilian agri-food system. However, this strategy depends on other strategies (e.g. ***promote sustainable technology***, ***public policies to promote sustainability***, ***financing and credit for sustainability***, ***technical assistance***) to implement an agri-food system based on 'better management practices' for production. The central measure is the intensification of livestock and agrosilvopastoral systems aligned with sustainability criteria, since livestock has the biggest lack of sustainability in the Brazilian food production according to stakeholders, literature review (chapter 2) and results of

chapter 4. Private and governmental certification are important mechanisms to stimulate better management practices. Other measures relate to the efficiency of machinery and equipment in the use of energy and resources, control of agrochemicals and strong government incentives and enforcement to ensure better management practices.

Promote sustainable technology is the strategy to develop sustainable technologies to support the establishment of ***better management practices*** through ***technical assistance***. The main objective is to align with the sustainability criteria, any investment and initiatives of research or development of technology for food production and consumption, considering both conventional and sustainable agriculture. Some important measures are the increase of investment in research, exchanges between researchers, rural extensionists and farmers, the improvement of quantity and quality of the transfer of technology, increase in efficiency of renewable energy sources, combine the use of technology with environmental and territorial regulation.

Some aspects of the ***education, research and university extension*** strategy also are part of the core ideas of the vision. According to stakeholders, formal education, for example, is one solution to increase awareness of the population about the needs to improve the sustainability of the agri-food system. Reshaping the curriculum of basic education and agricultural courses based on sustainability principles and enhancing citizenship values are central measures for this strategy. Promoting university extension and partnerships between researchers, rural extensionists and farmers are important steps in this strategy.

Other strategies are welcome and complementary to create the narrative for the implementation of In-depth vision, although they are not priority:

Social governance – It is the government's role to create and expand mechanisms to improve social governance; however, this is not a priority strategy. Nevertheless, the establishment of a more participatory and decentralized system for the management of natural resources is complementary to the implementation of the vision.

Local, sustainable and decentralized agriculture – The strategy is complementary and important, however the focus and priority is on the improvement of sustainability

by the dissemination of ***better management practices*** through ***technical assistance*** independent on whether it is for conventional or for sustainable agriculture. The strategy is also an output of the vision, but less important than ***better management practices***.

Communication and campaign – It is also complementary, however it is not a priority strategy. In this vision, government is the main promoter of communication with society about programmes and improvements into the Brazilian agri-food system. The promotion of an independent media and culture is unexploited.

Co-responsibility and sustainable consumption – Sustainable consumption is complementary and important for the vision. However, the development of spaces for co-responsibility of production and consumption, as CSA (community-supported agriculture, A.1.1), urban agriculture and solidarity economy, is underexploited. In addition, there is no policies or actions to reduce consumption of food from conventional agriculture.

Society mobilization – Society awareness and mobilization are complementary for the vision, however it is not a priority. Government acts directly to implement measures to improve sustainability, rather than creating spaces for society to do it. There is no intension to overthrow capitalism or make radical changes based on the use of precaution against environmental changes.

Radical transformation vision

The implementation of the radical transformation vision follows a bottom up approach. The catalyst points and central strategies are ***society mobilization*** and ***social governance*** (figure 7). Society is the main force to promote, to create mechanisms and spaces and to pressure and monitor the government to generate sustainability in the Brazilian agri-food system. The main mechanisms for implementation are ***education, research and university extension*** fostering society awareness towards mobilization and ***technical assistance***, primarily supporting small-scale family farmers and traditional communities to implement sustainable agriculture. The main sustainability outcome is a ***local, sustainable and decentralized agriculture***.

The attributes presented for the sustainability transition towards a Radical transformation vision coincide with the concept of strong ecological modernization pathway develop by Marsden (2013). In a transition to a strong ecological modernization, the dominant regime loses its legitimacy and the niches becomes the new paradigm. The development of an eco-economical place-based reflexive governance promotes more rooted forms of sustainability, creating new policy space, vectors and frameworks and re-calibrating the power relations between production and consumption interests.
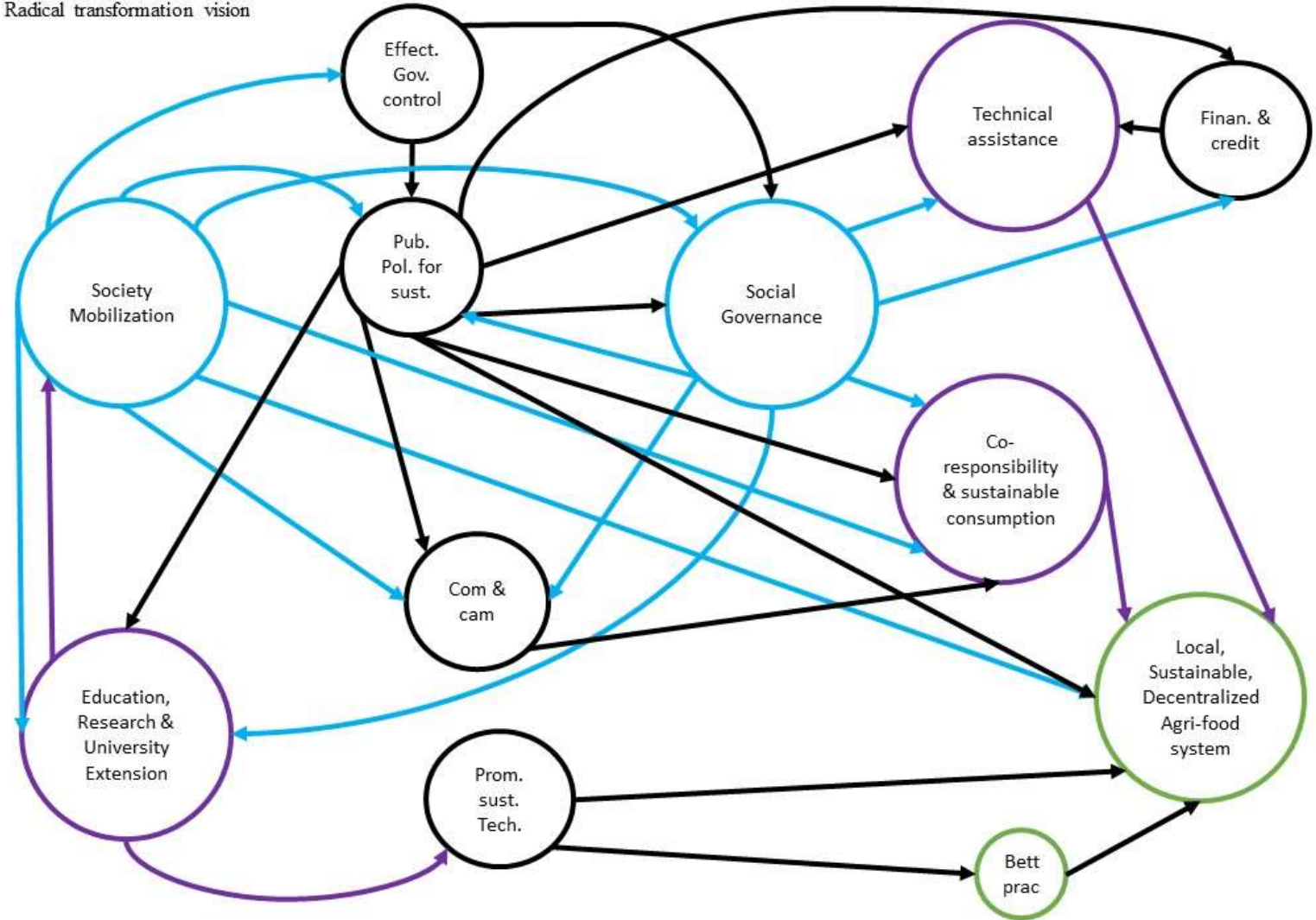
Figure 7. Radical transformation vision diagram

The main measures (darker green squares in the Appendices 13 and 14) to create the narrative for the implementation of the radical transformation vision are concentrated in the strategies:

Society mobilization – This is the fundamental strategy and the starting process of change for the vision. The mechanism is based on society and individual people assuming responsibility, creating and occupying space for change. The strategy encourages several simultaneous measures such as citizens voting better, support and engaging with NGOs, actively participating in social movements, strongly demanding government changes. It also incorporates initiatives from non-governmental stakeholders to pressure the government to create public policies aligned with sustainability goals (coalition NGOs and business, e.g.), more effective society control of politics and forms of representation, solidarity economy, CSA, urban agriculture, participatory councils, articulation and decision networks for sustainability, cooperatives. It also includes ambitious aims such as the overthrowing of capitalism and radical changes as a precaution against environmental changes.

Social governance – Society actions and responsibility for change are central to the implementation of the vision. Therefore, ***social governance*** together with ***society mobilization*** are essential strategies and catalyst points to improve the sustainability of the Brazilian agri-food system. In essence, the mechanism to improve ***social governance*** is to create horizontal, territorial, participatory, democratic, decentralized and less bureaucratic systems of management of natural resources to enlarge the spaces of decision-making and citizenship. Some of these instruments already exist in Brazil; however, they need consolidation and expansion, such as ZEE, basin committees, PLANAPO (National Plan for Agroecology and Organic Production), law of cities, municipal master plans, etc.

Education, research and university extension – Education is at the heart of the vision because it is the driving force to mobilize society for change. Formal and informal education in urban and rural areas, are a solution to raise the populations' awareness about the need to improve the sustainability of the agri-food system. Similar to the In-depth reform, one the most significant measures for this strategy is the reshaping of the curriculum of basic education and agricultural courses. The reshaping should be based on a systemic, participatory and adaptive education, environmental education, sustainability principles, promotion of art and culture and enhancement of planetary

citizenship values. Some of the values foster care of the local space, love and respect of the land, water and processes of producing food, understanding the environment as an asset and not an obstacle to food production. Universities' rural extension and partnerships between researches, rural extensionists and farmers is also an important part of the strategy to promote sustainable agriculture.

Co-responsibility and sustainable consumption – This strategy is also central to the vision. It is the action, which arises from societal mobilization, i.e., society taking responsibility for change through sustainable consumption and a direct link to the sustainability of production of food and its whole supply chain. Some important measures for this strategy are promoting CSA, direct purchasing from farmers of local and seasoned products, solidarity economy, urban agriculture and rejecting food from conventional agriculture and ultra-processed food.

Communication and campaign – This is an important strategy to promote sustainability concepts and successful sustainability experiences about production and consumption of food using social networks, alternative media and blogs to inform society that change is possible. The mechanism is to promote free media and culture that operates independently of the control of government and powerful business groups.

Technical assistance – Similar to In-depth reform vision. However, what differentiates the visions is that the In-depth reform considers sustainability criteria based on ***better management practices*** for all farmers practicing both conventional and sustainable agriculture. On the other hand, the Radical transformation vision considers sustainability criteria based only on sustainable agriculture directed exclusively to small-scale family farmers, medium-scale farmers and traditional communities. The technology transferred to farmers comes from the knowledge compiled from an intense partnership between universities, research institutes, government, rural extensionists, traditional communities and small-scale family farmers.

Local, sustainable and decentralized agriculture – It is a central strategy, whose measures directly help to reach the final aim of the vision, i.e. to promote a local, sustainable and decentralized agriculture. The focus is on the dissemination of sustainable agriculture through ***technical assistance***. The specific mechanisms of this

strategy are to create space, initiatives, policies and investments for sustainable and local agriculture from local and medium-scale farmers. The expansion of governmental programmes like PPA (Food Acquisition Programme) and PNAE (National School Feeding Programme), are the most important measures. Other measures are to build regional business models for family farming, decentralized trade structures, open markets and ensure good prices to farmers and at the same time affordable prices to consumers.

Financing and credit – This strategy is the condition to enable the implementation of sustainable agriculture by small-scale family farmers (especially small undercapitalized farmers) and medium-scale farmers through the guarantee of credit and financial incentives through governmental programmes like PPA. Offers of credit depend on compliance with sustainability criteria regarding sustainable agriculture, and it links to long-term planning focused on the local territory, access to land and *technical assistance*. It incentivises the development of chains from local products and industry and it does not support chains with a high dependency on oil. An important step in the strategy is to support funders with the development of decision-making mechanisms based on sustainability criteria and indicators. Accountability of social and environmental externalities and costs are also priority. There is no public finance and credit support for conventional agriculture, only through private sources.

Other strategies are welcome and complementary to create the narrative for the implementation of Radical transformation vision, although they are not priority:

Public policies for sustainability – Public policies and government action are very important for the implementation of the vision; however, society is the main driver to induce change and improvements of policies through *social governance* and *societal mobilization*. Similar to the in-depth reform vision, the challenge is to subordinate all public policies under the criteria of sustainability, taking into account small-scale family farmers, traditional communities and the domestic market as a strategic focus for the country. Measures are more radical than those from the In-depth reform and focused on small-scale family farmers and traditional communities. It also creates and strengthens policies for medium-scale farmers. Some examples are tax reductions for sustainable production, support the market for sociobiodiversity, land reform

restricting the size of properties, strengthen policies for traditional communities, strengthen CONDRAF (National Council on Sustainable Rural Development) and PLANAPO, and create policies for the return of the population to rural areas.

Effective government control – Government control is complementary to the vision, especially when restricting the concentration of power from market forces, big farmers and media, environmental and land tenure regulation. However, in some cases, excessive governmental control can inhibit or even coerce society participation and freedom.

Promote sustainable technology – the main objective of the strategy is to align with the sustainability criteria, any investment and initiatives of research or development of technology for food production and consumption, considering only sustainable agriculture. Some important measures are increased investment in research, exchanges between researchers, rural extensionists and farmers, and improvement of the quantity and quality of technology transfers. Other measures provide access to technology and health in agricultural work for small-scale family farmers, using the current structure to develop new technologies with a long-term sustainability vision associated with agroecological systems, strengthened sustainable social technologies, integration of technology and ecology.

Better management practices – The vision considers the production of food from the perspective of broad sustainability, aiming the conversion of all conventional agriculture to sustainable agriculture. As better management practices link with responsible agriculture, they are important and complementary to the vision, especially to improve the current highly unsustainable livestock systems and to support a transition from conventional to sustainable agriculture. The strategy is also an output, but it is not a priority for the vision.

Scenario sustainability analysis

I classify the main **opportunities** and **barriers** mentioned by stakeholders for the improvement of the sustainability of the Brazilian agri-food system according to their applicability to the visions: high applicability (green), applicable (yellow) and low applicability (orange) (tables 12 and 13, respectively). Thus, it is possible to identify how the two visions relate to these parameters. I use the same classification to identify

how 'who would contribute' and 'who would oppose' the implementation of sustainability would apply and affect both visions (tables 14 and 15, respectively). In addition, I compare the performance of the two visions regarding the **problems** and **solutions** for the Brazilian agri-food system mentioned by stakeholders. Finally, I analyse how the performance of the visions would be according to the **hierarchical indicator framework** developed in chapter 4.

Opportunities (based on answers for the question B.8 of the interview, appendix 2)

Potentially, the Radical transformation vision would more easily incorporate the opportunities to improve the sustainability of the Brazilian agri-food system mentioned by the stakeholders. I consider this vision highly applicable to sixteen out of the twenty-two opportunities, while I find only five of these opportunities highly applicable to the In-depth reform (table 12, in green). I discuss the opportunities in four groups:

1. Some opportunities closely link to the core ideas of the Radical transformation vision, such as use of sociobiodiversity, existence of demands from society, societal mobilization and existent examples of sustainable production without the use of agrochemicals. These examples can be complementary to the In-depth reform vision; however, they are not priority and have low applicability to this vision (orange, table 12).

2. There is another group of opportunities also more applicable (high applicability, green) to the Radical transformation propositions than to the In-depth reform ones (applicable in yellow, table 12). They relate to society demands and mobilization (including a gastronomic movement) and some new public policies (PAA, PNAE, and PLANAPO) that closely suit Radical transformation ideas.

3. I consider opportunities such as the use of biodiversity to access new markets, a detailed labelling system, the strength of the Brazilian capacity to generate research and technology in agriculture, the implementation of the CAR (Rural Land and Environmental Management Registry) and the use of the current crisis as an opportunity equally important for both visions.

4. The last three opportunities closely relate (high applicability, green) to the In-depth reform ideas for market mechanisms as payment for ecosystem services and international demands for changes. UN policies such as international agreements are applicable and complementary to Radical transformation; however, it is not priority for the vision. On the other hand, pressure for changes coming from international companies has very low applicability for Radical transformation.

Table 12. Analysis of the applicability of opportunities to the visions

Opportunity	Details	In-depth Reform	Radical transformation
Socio-biodiversity	Understand and use in moderation biodiversity, natural resources, high social capital, human diversity, food diversity	Low applicability	High applicability
Society demands for change	It is not difficult to create an argument against the current system that is completely unsustainable, an opportunity to mobilize society and for change	Low applicability	High applicability
The mobilization of society	The CSA Brazil movement is growing, as well as ecological food street markets and networks for seed exchange	Low applicability	High applicability
The mobilization of society	An opportunity to bring agrarian reform movements closer to the middle class, since these issues of agriculture are distant from people's lives	Low applicability	High applicability
Sustainable production	Broad results of healthy and sustainable food production, agroecology, agroforestry, family farming, overcoming the false belief that it is not possible to produce without chemicals	Low applicability	High applicability
Society demands for change	There is concern about the environment and health	Applicable	High applicability

Society demands for change	Climate change issues can be an opportunity, because it makes people think about the future, opening up new possibilities	Applicable	High applicability
The mobilization of society	There is an increase in the production and consumption of organic products	Applicable	High applicability
New public policies	PAA (Programme of Food Acquisition)	Applicable	High applicability
New public policies	PNAE (National School Feeding Programme)	Applicable	High applicability
New public policies	PLANAPO (National Plan for Agroecology and Organic Production)	Applicable	High applicability
Society in network	Great ability to inform and value sustainable experiences, the opportunity to carry out an awareness campaign on consumption	Applicable	High applicability
Socioenvironmental movement	Brazil has a socio-environmental movement highly qualified in technical and scientific terms, an opportunity to consolidate sustainability in the country	Applicable	High applicability
Gastronomy for sustainable	There is a gastronomic movement in the Brazilian middle class that seeks to value and consume more sustainable foods. This can serve as a stimulus for the whole society	Applicable	High applicability
New public policies	Implementation of the CAR	High applicability	High applicability
Biodiversity	Knowing and using native products is the best way to conserve biodiversity and an opportunity to access new domestic and international markets	Applicable	High applicability
Labelling	A detailed food labelling system would be an important complementary	Applicable	Applicable
The current crisis is an opportunity to generate overcoming		Applicable	Applicable

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Research and technology for sustainability	Strong capacity of the country to generate sustainable research and technology. Academia, universities, research institutes and EMBRAPA (Brazilian Agriculture Research Corporation) are seeking this path	Applicable	Applicable
International demands for change	Multilateralism in international policies within the UN framework, offers similar pressure to Brazilian goals for climate conference, reduction of greenhouse gas emissions and low carbon agriculture	High applicability	Applicable
International demands for change	International companies and private sector leadership committed to sustainability and operating in Brazil increase the pressure for changes	High applicability	Low applicability
Payment for environmental services	Opportunity to use domestic and international resources to increase farmers' sustainability through conservation of natural resources	High applicability	Low applicability

Barriers (based on answers for the question B.8 of the interview, appendix 2)

I discuss barriers in three groups:

1. Similar to the opportunities, several barriers to improve the sustainability of the Brazilian agri-food system mentioned by stakeholders affect the Radical transformation vision (high applicability, green, table 13) greater than the In-depth reform (low applicability, orange, table 13). The barriers are individual and collective apathy towards change, international agreements that keep Brazil as a producer of a few agricultural commodities and the dominance of big companies in agricultural research and technology.

2. Other barriers also have a greater impact on the Radical transformation vision. Although they can pose difficulties to the implementation of the In-depth reform vision, some of them could benefit conventional agriculture to the detriment of small-scale family farmers and sustainable agriculture. Many of them relate to the economic and political power of a small group of the Brazilian elite, politicians and big corporations. This group controls the media

and all levels of government through the financing of electoral campaigns or corruption, institutions, etc. Some stakeholders consider politicians and government as the biggest barrier to improve the sustainability of the Brazilian agri-food system, preventing human, social and economic development based on education, health, collective wellbeing and social equity. Other barriers in this group are the lack of information to the population about good sustainability experiences, several dimensions of inequality that prevent participation and empowerment of individuals within society, the apathy of social movements waiting for governmental support and the consumerism of the population.

3. The remaining barriers equally inhibit the implementation of both visions. They are the precariousness of technical assistance, the lack of quality education and awareness, the huge problems of inequality that draw attention from the sustainability agenda and the bureaucracy of some policies and laws.

Table 13. Analysis on how barriers can affect the visions

Barriers	Details	In-depth Reform	Radical transformation
Individual and collective inertia	People believe that they do not make a difference, that there is no point in doing anything and this brings immobility, and apathy for change by the people	Low applicability	High applicability
Inequality between countries	Some actors consider that international agreements keep Brazil a commodity producer, and the country's main investments in this direction (research, infrastructure, tax exemption), and this is the main factor that prevents the advance of agroecology in the country	Low applicability	High applicability
Business as usual dominance over research		Low applicability	High applicability

Economic and political power and interests	Dominance of very heavy economic interests, an archaic view that does not benefit the country, only a few groups	Low applicability	High applicability
Economic and political power and interests	Brazilian elite fight to keep the current system (Economic powers, large corporations, capitalist system). They are impediments to economic, social and human development, based on education, health, collective well-being, social equity, and general development of the whole society	Low applicability	High applicability
Economic and political power and interests	Economic power is tied to and controls political power, as politicians and governments provide favours to big corporations (corruption, impunity)	Low applicability	High applicability
Economic and political power and interests	The elite has the power to form and consolidate opinions, which greatly undermines the quality of Brazilian democracy. The most powerful politicians have success in their election campaigns and therefore conquer more power. The result is totally unqualified people in power (government)	Low applicability	High applicability
Economic and political power and interests	Because of the relations between economic and political power, many actors consider the government and politicians the greatest barriers to the improvement of the agri-food system	Low applicability	High applicability
Lack of information	There is limited information or propaganda about good experiences in agriculture, which leads to the consolidation of conservative thinking and aversion to the risk of change	Applicable	High applicability
Inequality	Inequality is a strong process of exclusion, it prevents people from perceiving themselves as individual, participants and empowered throughout this process. There are	Applicable	High applicability

	inequalities in all senses, political, social, in access to land, income etc.		
Individual and collective inertia	There is also apathy in the sponsoring (by the government) of social movements, hoping that the government will support and serve them	Applicable	High applicability
Culture of consumption		Applicable	High applicability
Inequality	Problems "theoretically more serious" also draw attention from the environmental agenda and sustainability. People still do not see food as insecurity, there are more urgent things like security, education, income and employment	High applicability	High applicability
Lack of quality in education and awareness	Low quality education is an obstacle to having more critical citizens in relation to environmental awareness and for everything else	High applicability	High applicability
Technical assistance		High applicability	High applicability
Bureaucracy	Some policies and laws, rather than promoting sustainability, can make it more difficult. Access to credit is difficult and bureaucratic, for example. There are also difficulties to collect native seeds for the reproduction of seedlings for the restoration of areas	Applicable	Applicable

Who should contribute to improve the sustainability of the Brazilian agri-food system (based on answers for the question B.9 of the interview, appendix 2)

This section is a compilation of stakeholders' opinion of 'who should contribute' to the implementation of sustainability. I divide them into bottom up and top down contributors and contributory processes as discussed below and in table 14.

Bottom up contributors

As Radical transformation has a bottom up approach, actions coming from societal mobilization, agroecological farmers, independent and free media are highly applicable for the implementation of the vision. However, they are not central stakeholders for In-depth reform (low applicability or applicable). Other bottom up contributions such as researchers and health professionals are equally important for both visions. On the other hand, actions involving national and international big companies, standard media and large farmers are not central to the Radical transformation vision (low applicability), however they are essential for In-depth reform vision (high applicability and applicable).

Top down contributors

As In-depth reform has a top down approach, government based actions are highly applicable for the implementation of the visions. Therefore, EMBRAPA, Governmental research institutes, MMA (Environmental Ministry), MAPA (Ministry of Agriculture, Livestock, and Food Supply) and the Federal government (including the president of the republic) are the relevant stakeholders to implement the In-depth reform vision. Governmental institutions or councils that have strong societal participation like ZEE, CONDRAF, CONAMA (National Environment Council) and governmental technical assistance agencies are not central to In-depth reform, however they contribute greatly to the implementation of Radical transformation. Technical assistance agencies, ZEE and CMN (National Monetary Council) are equally important for both visions.

Contributory process

In terms of process, both visions rely on principles of sustainability to be effectively present in all public policies, however, their aims of sustainability are different as explained in the transition pathways for the implementation of the visions (see section Development of transition pathways for the sustainability of the Brazilian agri-food system, page 119). Conflicts within the traditional structure of power over the local territory is essential for Radical transformation and not applicable for In-depth reform.

Table 14. Contributors to the implementation of visions

Who would contribute	Details	"In-depth Reform"	"Radical transformation"
Bottom up	Agroecological farmers	Low applicability	High applicability
Bottom up	Independent and free media	Low applicability	High applicability
Bottom up	Small farmers	Applicable	High applicability
Bottom up	Qualified participation of civil society	Applicable	High applicability
Bottom up	A networked society, organized, mobilized to pressure decision-makers	Applicable	High applicability
Bottom up	Social movements, NGOs, associations, civil society	Applicable	High applicability
Bottom up	Civil society initiatives and national and international companies pressing the government	Applicable	High applicability
Bottom up	All, us, conscious people, several fronts	Applicable	High applicability
Bottom up	Academia	Applicable	Applicable
Bottom up	Health professionals	Applicable	Applicable
Bottom up	Media	Applicable	Low applicability
Bottom up	big companies	High applicability	Low applicability
Bottom up	large farmers	High applicability	Low applicability
Top down	Federal government, President of the Republic	High applicability	Low applicability

Top down	EMBRAPA, technologies of social and productive inclusion	High applicability	Applicable
Top down	Research institutes (IPEA - The Institute for Applied Economic Research, IBGE - Brazilian Institute of Geography and Statistics, Universities)	High applicability	Applicable
Top down	MMA's Regulation and monitoring	High applicability	Applicable
Top down	MAPA, to take an agricultural policy for the transition to sustainability	High applicability	Applicable
Top down	Economic Ecologic Zoning (ZEE)	High applicability	High applicability
Top down	Technical assistance agencies	High applicability	High applicability
Top down	CMN (National Monetary Council), offer differentials for sustainable practices	Applicable	Applicable
Top down	National Council for Rural Sustainable Development (CONDRAF)	Applicable	High applicability
Top down	National Environment Council (CONAMA)	Applicable	High applicability
Top down	Conferences, meetings or regional panels, participatory councils	Low applicability	High applicability
Process	Conflicts with the traditional power structure over the territory	Low applicability	High applicability
Process	Principles of sustainability present effectively in all public policies	High applicability	High applicability

Who would oppose the improvement of the sustainability of the Brazilian agri-food system? (based on answers for the question B.10 of the interview, appendix 2)

I found two types of opposition to the improvement of sustainability of the Brazilian agri-food system from stakeholders' feedbacks: subjects of opposition and proceedings of opposition (see table 15).

Subjects of opposition

According to stakeholders, there is a small group of beneficiaries of the current agri-food system model and situation. They would oppose the ideas of Radical transformation vision more strongly, considered in this case, highly applicable (green, table 15) to prevent the implementation of the vision. This group would not oppose the ideas of In-depth reform vision with the same intensity, because they strongly rely on conventional agriculture for export and high intensive technology and inputs (machinery, oil, agrochemicals). According to stakeholders, they are part of the dominant class, big industries of agribusiness, multinational companies who sell agrochemicals, machinery, antibiotics and seeds, big industries of food markets, pharmacy industry, large farmers, groups financing politicians' campaigns and influencing government (including MAPA) to strengthen conventional agriculture for export. A group of politicians broadly mentioned as the biggest opponents of sustainability are the members of the BBB (cattle, bible and bullet) group representing the agribusiness lobby in the Brazilian lower house. Some stakeholders also cited members of the Judiciary and people who have apathy for a transformation as opponents of sustainability. They would affect both visions.

Proceedings of opposition

Stakeholders also refer to processes that would oppose changes towards sustainability. Similar to the other opponents, these processes would oppose the core ideas of the Radical transformation vision (high applicability) more intensively than the In-depth reform (low applicability and applicable) ones. These processes refer to the Brazilian agri-food system mainstream based on an agriculture of high inputs and exports, consumerism, public policies and governance oriented by economic interests and corruption, lack of respect for traditional culture and communal use of natural resources. On the other hand, the lack of big infrastructure for commodity exports would affect the implementation of In-depth reform (high applicability, green) more than Radical transformation (low applicability, orange).

Table 15. Opponents to the implementation of visions

Who would oppose	Details	In-depth Reform	Radical transformation
Opposition subjects	Dominant class; Large economic interests, small group formed by the people who benefit from the current situation. Group finances (traditional rural lobby) politicians of all major parties and directly influence various areas of government, mainly MAPA; Agribusiness - large industries (multinational companies, fertilizers, agrochemicals, antibiotics and seeds); Who sells health, pharmacy (are the same companies of agrochemicals); Who sells food and loses with farmers' fair	Low applicability	High applicability
Opposition subjects	Large commercial producers, large farmers	Low applicability	High applicability
Opposition subjects	Chamber of deputies, BBB lobby (cattle, bible and bullet); Political sector - "ruralista" lobby (BBB) in the Lower and Upper House who represents interests of very strong industrial groups, agroindustry; There are many opponents of these changes in the federal government as well, inside the Brazilian state	Applicable	High applicability
Opposition subjects	judicial power	Applicable	High applicability
Opposition subjects	People apathetic to a transformation: who do not care about health, who have no idea what a product is without pesticides, who are afraid to face this change	Applicable	High applicability
Opposition proceedings	Productivist model of international competition, economic immediacy and unsustainable consumption	Low applicability	High applicability

Opposition proceedings	lack of democracy in information ("post-truth")	Applicable	High applicability
Opposition proceedings	Ecological economic zoning, political, commercial and economic interests	Applicable	High applicability
Opposition proceedings	Lack of respect for traditional knowledge and lack of commitment to social and environmental issues	Applicable	High applicability
Opposition proceedings	Agrochemicals marketing model	Applicable	High applicability
Opposition proceedings	public policy	Applicable	High applicability
Opposition proceedings	Flagrant Brazilian corruption that renders the political sphere as merely serving the structures of economic power is the great aggravating factor of this process of continued unsustainability	Applicable	High applicability
Opposition proceedings	Low infrastructure development	High applicability	Low applicability

Problems of the Brazilian agri-food system (based on answers for the question A.1 of the interview, appendix 2)

Overall, the ideas and propositions of the Radical transformation vision address the existent problems of the Brazilian agri-food system cited by stakeholders better than the In-depth reform vision. According to several stakeholders, the current agri-food system has serious negative consequences for the environment, inequality and quality of people's lives, especially the poorest people and traditional communities. These statements corroborate the results found in chapter 4 and the literature review (chapter 2). For some stakeholders, the origin of the problem is the disproportionately high public support given to the large farmers, which engage in conventional production over the small-scale family farmers engaging in sustainable agriculture. This generates a hegemonic model oriented by commodification, exportation and a low value-added system. The In-depth reform does not properly address these problems, once the credit is offered equally to all farmers independently to the size of the farm, based on better management practices criteria. Radical transformation addresses these problems by restricting public support to small-scale family farmers and making conditioning the

practice of sustainable agriculture (see section Development of transition pathways for the sustainability of the Brazilian agri-food system in this chapter).

The Radical transformation vision better addresses other specific problems in the Brazilian agri-food system, for instance, the intensive use of agrochemicals and the lack of population awareness and knowledge. Other two problems primarily faced by Radical transformation and not properly addressed by In-depth reform are the high dependency on external inputs by the conventional agricultural system and the loss of traditional culture. Social inequality is another huge challenge for the country and, consequently for the Brazilian agri-food system (see IPEA, 2014). The In-depth reform vision faces the problem of promoting the population's access to safe and nutritious food and access to credit linked to responsible production. Overcoming social inequality is a priority for the Radical transformation vision, which takes into account land reform by restricting the size of rural properties and redistributing wealth and the means of production.

Both visions equally address the degradation of ecosystem services, the lack of interest of the government to change the situation and waste in production, distribution and consumption of food. On the other hand, the In-depth reform vision addresses more substantially the lack of environmental control, inspection and regularization and the low level of development and investment in infrastructure.

Solutions for the Brazilian agri-food system (based on answers for the question A.2 of the interview, appendix 2)

The Radical transformation vision promotes bottom up solutions more strongly, such as improving society awareness to generate the transition to sustainability and developing co-responsibility between farmers and consumers for sustainability. It also addresses policies to reduce social inequality better than the In-depth reform vision does. Additionally, in contrast to the In-depth reform vision, Radical transformation prioritizes the creation of more space for society articulation, policies and investment to promote local and sustainable agriculture, and the facilitation of public access to finance for small-scale family farmers and medium-scale farmers.

Both visions equally address the improvement of natural resource management, the massive investment in technical assistance and the conversion and adaptation of public policies for sustainability and conservation of ecosystem services.

On the other hand, the In-depth reform vision addresses top down solutions such as firmer action by the government in controlling the food production process and investment in infrastructure and logistics better than the Radical transformation vision does.

Analysis of visions in comparison to indicators of sustainability of the Brazilian agri-food system

Based on criteria of the hierarchical indicator framework from chapter 4:

Equity & social welfare

Both visions would keep the improvement of indicators related to dietary consumption, access of water and sanitation in rural areas and the eradication of slavery work. Radical transformation would provide better improvement on indicators related to employment and minimum wage for the population because of its focus on the development of small farmers. According to MDA (2009), small-scale family farmers employ more people per area and generate more income per worker than large farms (MDA, 2009). Similarly, because of its strong emphasis on land and wealth distribution, the Radical transformation vision would perform better in indicators like the Gini Index, land distribution for agriculture use, share of poorest and richest quintile in national consumption (especially in rural areas, but also in urban areas due to the return of some people to rural areas).

Economic stability & investment in infrastructure, research and technology

Both visions would keep the current positive agricultural balance of trade in Brazil. However, the In-depth reform would have vastly more export surplus than Radical transformation due to its focus on the development of markets for agricultural commodities for export. There would be a balance on the percentage of total GDP from

agriculture for both visions. On one hand, because of the In-depth reform financial return with the development of agricultural commodities. On the other side, because of the Radical transformation gains with the development of domestic market such as creation of new jobs in small farms (that employ more people per area and generate more income per worker than bigger farms (MDA, 2009)) and in the new supply chain for a more varied agricultural and aquaculture products. Conversely, the In-depth reform would have much higher investment in large infrastructure such as road and railways.

Culture and traditional preservation

The Radical transformation vision would improve the indicators of this criterion because preservation of culture and traditional communities are central to this vision. For instance, trends in the degree to which 'traditional knowledge and practices are respected' would increase with the participation of traditional communities and small-scale family farmers in the design of the sustainable agriculture technologies transferred by technical assistance. Similarly, trends of linguistic diversity and in genetic diversity of cultivated plants would benefit from this policy and by the prioritization of public support and credit incentives to small-scale family farmers and traditional communities. Finally, trends in the area of forest, agricultural and aquaculture ecosystems under sustainable management would improve drastically with Radical transformation since the aim of the vision is to develop sustainable agriculture and eliminate conventional agriculture from the Brazilian agri-food system. In-depth reform would also increase the use of sustainable agriculture and the level of sustainability of conventional agriculture; however, the improvements in sustainable management would be more modest than in Radical transformation. However, with the continuation of the large amount of government support to conventional agriculture, trends of linguistic diversity and trends in genetic diversity of cultivated plants would deteriorate.

Ecosystem services provision & biodiversity conservation

Both visions care about the environment and conservation, so they would keep high levels of the proportion of land area covered with forest. However, Radical transformation would be more efficient in this indicator because it encourages the use of agroforestry, which would increase the area of forest cover in Brazilian landscapes. Also, agroforestry would reduce the proportion of some species threatened with extinction, providing feasible habit (refugees) or improving the connectivity of the landscape, becoming corridors or stepping stones for the dispersion of these and other species. Although the In-depth reform would improve the current low performance of the indicators related to the provision of ecosystem services, the Radical transformation vision would be more efficient due to the massive use of sustainable agriculture. On the other hand, there would be no improvement in the proportion of fish stocks within safe biological limits for either visions, because they do not contain elements to improve this aspect.

Use of natural resources & pollution

Both visions have a strong concern about the use of natural resources and pollution, hence the indicators of this criterion such as carbon emissions and quality of water would follow the current trend of improvement for both visions. However, Radical transformation would have better performance to improve the quality of water because of the big reduction in the use of external inputs (agrochemicals) for agricultural production. In addition, the intense use of agroforestry in this vision would benefit the environment due to the storage of carbon in soil and vegetation.

6.4. Discussion

My objective in this chapter is to build transition pathways towards a sustainable Brazilian agri-food system from the two future visions of sustainability developed with stakeholders in Brazil: Radical transformation and In-depth reform. If accomplished, the Radical transformation vision would provide broader and deeper sustainability achievements than In-depth reform, taking as reference the agri-food system

sustainability concept adopted in the chapter 4. On the other hand, In-depth reform is more realistic to be implemented than the Radical transformation vision, which is very unlikely to become the mainstream in the Brazilian agri-food system in the short or medium term. Three fundamental elements show that Radical transformation has higher sustainability performance than In-depth reform.

First is the scope of sustainability that makes up the central ideas of the vision. In chapter 4, adapted from Ericksen (2008), I define the concept of sustainability of agri-food systems as the well-functioning / quality of the three outcomes of the system, i. e. human wellbeing, food security/sovereignty and environmental quality. Beyond the concept of food production and consumption, this broad perspective of sustainability incorporates aspects of multi-functionality, multidimensionality and policy relevance of the agri-food system. In-depth reform is policy relevant because it complies with UN policies of food security, i.e. physical and economic access to safe and nutritious food for all people (FAO, 1996). However, it does not fully incorporate the multi-functionality and multidimensionality of the system (Loiseau et al., 2012; IAASTD, 2009), as Radical transformation does. The latter vison embraces aspects of food sovereignty perspectives of the agri-food system, incorporating not only the idea of the right to food, but also the right to produce food, which also gives this vison higher performance in human wellbeing (e.g. "redistribution of land and wealth", "equity in distribution", respect for traditional knowledge", "direct relation farmer-consumer beyond the logic of the market", table 10, chapter 5). Radical transformation also performs better in environmental quality, because its agroecological productive systems (e.g. "production diversification (integration, agroforestry systems)", "chemical-free system", "values socio-biodiversity", "do not use GMOs", table 10, chapter 5) are more efficient to guarantee functionality (multi-functionality and multidimensionality) of the ecosystem than conventional agriculture ("qualified technical assistance to all, focused on sustainability", "better management practices on agriculture and cattle ranching", "appropriate labelling of GMOs", table 10, chapter 5), which is the mainstream practice in the In-depth reform vision.

Second, the scenario sustainability analysis presented in this chapter reveals that the Radical transformation vision is more adequate to address the problems of the Brazilian agri-food system cited by stakeholders (section 6.3, this chapter). In general, this vision performs better to improve criteria of sustainability of the hierarchical

indicator framework developed in chapter 4 to assess the sustainability of agri-food systems.

Third, Radical transformation's approach to implementing sustainability brings more sustainability (figure 7) than the In-depth reform approach (figure 6). The final aim of the Radical transformation vision is the total conversion of the agri-food system towards the sustainable agriculture focused on small-scale family farmers, medium-scale farmers and traditional communities ("'agroflorestar' the planet", table 10, chapter 5, "public support gradually transferred to sustainable agriculture from small-scale family farmers and medium-scale farmers", table 11, chapter 5). The In-depth reform vision aims for the establishment of better management practices over the food supply chain, including some practices of sustainable agriculture, taking into consideration all farmers ("qualified technical assistance to all, focused on sustainability", "better practices on agriculture and cattle ranching", table 10, chapter 5). The Radical transformation approach would bring more improvements for the three outcomes of the agri-food system, i.e. human wellbeing, food security/food sovereignty and environmental quality than the In-depth approach would. For instance, the Radical transformation approach would deliver stronger outputs for the distribution of land and wealth, quantity and quality of jobs, quality of food and diet, provision of ecosystem services etc (e.g. "redistribution of land and wealth", "agrochemicals moratorium", "encourage people to return and remain in the field", "encourage the consumption of local products", table 10, chapter 5). It is important to highlight that, even if In-depth reform is less sustainable than Radical transformation, it is still a major improvement for the Brazilian agri-food system compared to the current system.

For the reason that Radical transformation is far more sustainable than In-depth reform, it is also extremely more difficult to implement and very unlikely to happen, even though it brings much more benefits to society and environment and it is feasible to implement. I highlight three arguments that endorse the possibility to implement Radical transformation: the viability to feed the world by applying sustainable agriculture in the long term, existing policy and social governance to support the change, and existing social movement and society initiatives to boost the transition. First, according to Reganold et al. (2016), a blend of organic and other innovative farming systems are needed (e.g. agroforestry, integrated farming, conservation agriculture etc.), however it is possible to have future global food and ecosystem

security. Second, It already exist set of policies that can support the improvement of the sustainability of the Brazilian agri-food system and/or offer conditions to increase social governance, which consequently could benefit the implementation of Radical transformation (see chapter 2 and 7, Appendices 13 and 14). For instance, CONDRAF (National Council for Rural Development and Family Agriculture) and PLANAPO (National Plan for Agroecology and Organic Production) are spaces to build public policies with popular participation, and are made up half by government and half by civil society members. Other mechanisms in Brazil provide societal participation and strength the reflexive governance placed in Brazil (as mentioned by Sonnino et al., 2014), such as Ecological economic zoning, committee of hydrographic basin, law of cities, municipal master plans). PAA (Food Acquisition Programme) and PNAE (National School Feeding Programme) are two additional examples of policies that support small-scale family farmers applying sustainable agriculture. Third, society has created several movements that reinforce the conditions for the transition towards Radical transformation, such as community-supported agriculture movement, urban agriculture movement, solidarity economy, farmer's street market, cooperatives, associativism, etc. For instance, the ideological engagement and work of rural political organizations such as National Confederation of Workers in Agriculture (CONTAG), Federation of Workers in Family Agriculture (FETRAF) Landless Rural Workers' Movement (MST) responsible for the rise of agroecology in Brazil (Altieri & Toledo, 2011).

As previously mentioned, even if there are elements that favour the implementation of Radical transformation, it is very unlikely that this will occur in the short or medium term. Although the implementation of In-depth reform is more viable than Radical transformation, it is unlikely that it will occur in the short term. I highlight five factors that favour or hinder the implementation of the visions. First is the international agreements used as a reference in this research. The Radical transformation has more synergies with the Aichi targets, which is a UN framework for conservation of biological diversity, that also incorporates components for the preservation of traditional communities' knowledge and practices (UN, 2014). In-depth reform is more aligned with the international agenda for development, previously represented by the Millennium Development Goals and currently by the Sustainable Development Goals (UN, 2015). In-depth reform is more viable because the agenda for development

seems to have much more prestige than the agenda for biodiversity conservation with the Brazilian government and worldwide. Although the Brazilian government is a signatory of both agendas, none of them acts as a fundamental guide to orient Brazilian agri-food system policies; not even the development agenda (see chapter 2).

Second, the national agenda and policies for the agri-food system are closer to the In-depth reform vision than to the Radical transformation vision. Brazilian policies are also far from aligned to the broad sustainability agenda, taking the sustainable development of agribusiness based on technology transfer as a central reference (see chapter 2). The evidence for this is the vision of MAPA, the central institution for planning and managing the agri-food system in Brazil. MAPA's mission is to promote the sustainable development and the agribusiness competitiveness for the benefit of Brazilian society (MAPA, 2017). By this pattern, Brazil follows what Marsden (2013) calls Weak Ecological Modernization pathway where the agri-food regime maintains the dominant frameworks and gives a marginal role for the new niche players and the development of products/process centres in technological and best practice means.

Third, although there are several examples of sustainable agriculture taking place in Brazil, they remain a small niche. For example, according to IUCN (2011), only 0.25% of Brazilian agriculture was organic in 2011. This performance is very insignificant and the conversion of the entire system to sustainable agriculture, as aimed by Radical transformation, is extremely unlikely to happen in the short and medium term.

Fourth, the huge barriers mentioned by stakeholders can explain the improbability of a radical change in the Brazilian agri-food system. These barriers more strongly affect the Radical transformation vison than the In-depth reform vision (see analysis of barriers, table 13). Some of the most relevant barriers are individual and collective apathy towards change, international agreements that keep Brazil as a producer of few agricultural commodities and the dominance of big enterprises in agricultural research and technology (table 13). Similarly, according to stakeholders, the biggest opponents to change in the system are detrimental to Radical transformation such as the dominant classes, big agribusiness industries, multinational companies, pharmacy industry, large farmers and politician's membership of BBB (see analysis of opponents, table 15).

The fifth factor is the inability of social movements to expand successful local experiences to the national or regional scale and build a solid transition towards a

sustainable agri-food system in Brazil. There are several examples of urban agriculture, community supported agriculture, solidarity economy, communal gardens etc, which are not gaining scale and remain a local niche of sustainability. Radical transformation depends on societal mobilization to produce the changes it aims for. The opportunities to change the system suggested by stakeholders are highly and primarily applicable to the Radical transformation vision because they are mostly society based (see analysis of opportunities, table 12). However, the difficulties to overcome the structural, instrumental and discursive power (Fuchs et al., 2015, also see chapter 7) that keeps the Brazilian agri-food system unsustainable are still insurmountable and they will probably be so for a long time.

In summary, both visons are vulnerable to either the achievement of sustainability or the probability of implementation. In chapter 7, I present a combination of both visions to optimize achievement of sustainability and viability of implementation, providing general policy prescriptions and my suggestions for transition pathways to achieve sustainability in the Brazilian agri-food system.

6. 5. Conclusion

The implementation of the Radical transformation vision would bring more sustainability to the Brazilian agri-food system than the In-depth reform vision because it has a broader scope of sustainability, it better addresses current problems and it aims for more sustainable outcomes. Although the Radical transformation is technically implementable, it is very unlikely to happen. The reason is that it would find strong resistance from the powerful group who benefit from the current system, and because it relies on a transformation coming from an uninformed and apathetic society. The implementation of the In-depth reform would be very challenging; however, it is more feasible because it retains some of the structure of the current system, which would reduce the conflicts of interests with the group in power. As the In-depth reform is a top down approach, the biggest challenge of the vision is to have a government keen and determined to implement it. In chapter 7, I combine the strength of both visions and present alternative transition pathways and general policy prescription for a sustainable Brazilian agri-food system in chapter 7.

7

General discussion and recommendations

7.1. Preamble

The final aim of this research is to formulate and discuss transition pathways for a sustainable Brazilian agri-food system. In order to address this aim, I structure the discussion in three sections. First, I explore the two main drivers of the global agri-food system, according to researchers and international agencies: the need to (1) increase food production and (2) reduce the negative impacts of production. Then I present the gaps in the literature and outline my contribution based on the approach developed in this thesis (section 7.2). In the second section, I present specific problems and solutions for the Brazilian agri-food system, synthesizing the results of the framework used in this research (section 7.3). In the third section, I make recommendations for transition pathways to improve the sustainability of the Brazilian agri-food system, including limitations and refinement of the research (section 7.4).

7.2. Global food problems and the mainstream approach to solve them

Mainstream approaches to addressing global food problems aim generally to simultaneously increase food production, while reducing its negative impacts, see for example Godfray and Garnett (2014), Foley et al. (2009) and reports from international agencies such as FAO (2017), IAASTD (2009), Foresight (2011). This perspective is aligned with the discourse of food security, which advocates the increase of productivity through technological research, agricultural development and the market, as solutions for hunger and food insecurity (Jarosz, 2011). I argue in my thesis that even if this perspective has crucial and pertinent elements, it is still insufficient and too reductionist in scope to solve global agri-food system problems, especially in

adopting technocratic perspectives while neglecting essential issues such as inequality and power. According to FAO (2016: 8), "global food demand in 2050 is projected to increase by at least 60% above 2006 levels, driven by population and income growth, as well as rapid urbanization". Consequently, part of the solution to this problem is to increase global food production and productivity. This discourse is partially justifiable because of the rising demand for food; however, there are two central issues that undermine its validity.

Firstly, as mentioned by Patel (2012) and Tomlinson (2013), the supply of food itself does not guarantee the elimination of hunger (one of the most serious agri-food system problems) and even less so the inequalities in the agri-food system itself, as highlighted by Fuchs et al. (2015). The results from the indicator framework, chapter 4 of this thesis, show the Brazilian agri-food system with plenty of access to food, however a very unequal agri-food system (see table 8, IBGE, 2012, IPEA, 2014, FAOStat, 2017, chapter 4 and appendix 1). The people's right to food is recognized by many nation states and international agreements (Riol, 2017). However, 1/7th of the world population still does not have adequate access to food, even though there is enough food produced to feed everyone (FAO, 2017). According to De Schutter (2014: 1), the UN special rapporteur on the right to food from 2008 to 2014, "producing too much food is what starves the planet". The discourse of increasing productivity at any cost strengthens the power and interests of international traders. A narrow discourse of urgency to produce food masks the needs for equity and justice within the agri-food system and endorses neoliberal arguments of free market and technical revolution. This technocratic and productivist slant of the agri-food system has enabled increasing globalisation and concentration of power and wealth in the hands of a few traders to go virtually unchallenged, although these trends cause distortions in the price and availability of food, the impoverishment of small-scale family farmers, and the economic unviability of many small farms. Evidence of these phenomena also can be found in Lang & Rayner (2015), Hopma and Woods (2014), Global Network for the Right to Food and Nutrition (2014), De Schutter (2014), Marsden (2013), IAASTD (2009), Anderson (2009), Pechlaner and Otero (2008), Woods (2007) and Aksoy & Beghin (2005).

The second issue with narrow arguments advocating the increase of food production relates to the limits and risks of the mainstream mechanisms to increase productivity

Pittelkow (2015) and Foley et al. (2011). Although there is room for increased productivity in many agricultural systems, the mechanism in question is unsustainable, based on high external inputs of finite natural resources (see Smil, 2000, Zapata & Roy, 2004, Monfreda, 2008, Glendining et al., 2009, FAO, 2017, chapter 2). Higher inputs costs (mainly energy), fall in agriculture productivity, a growing scarcity of land and water, adverse weather conditions are key drivers of the increases in the scale of food production , but also of higher food prices (Dupont & Thirlwell, 2009 and Hanjra & Qureshi, 2010). Conventional agriculture, responsible for more than 95% of Brazilian agriculture for example, reduces agricultural resilience through the loss of food diversity (see FAOStat, 2017, chapter 4) and traditional community knowledge (see IUCN, 2011, chapter 4).

The second mainstream concern for the agri-food system, the environmental impacts of food production, is also limited and masks broader comprehension of the system. I found that environmental impacts are huge issues for the Brazilian agri-food system as found in the results of chapter 4 for ecosystem services, biodiversity conservation, use of natural resources, pollution (Santos et al., 2007, IUCN, 2011, Sparovek et al., 2011, MMA, 2017, FAOStat, 2017). Agriculture is one of the main components of environmental change, contributing to the overstepping of the planetary system (Rockstrom et al, 2009). Foresight (2011), for example, argues that many systems of food production are unsustainable because they are promoting degradation or over-extraction of soil, water, biodiversity, and fishing and are dependent on fossil fuels. Other authors alert about the effects of agrochemicals on humans (Boxall et al, 2009, Bandara et al., 2010), ecosystems (Solomon et al. 2000; Schriever et al. 2007) and water insecurity (Brown, 2005, Castillo et al., 2007, Allouche, 2011). However, as found in chapter 4, social, cultural and economic impacts are equally important issues for therazilian agri-food system (IBGE, 2012, IPEA, 2014).Binder et al. (2010) state that sustainable assessments in agriculture highlight environmental and technical issues, ignoring other elements of sustainability such as the social and economic aspects, multi-functionality of agriculture and the applicability of results. Although the mainstream concern for food production (to increase production and reduce impacts) are factual and very pertinent, they do not truly address the problematic status quo of the current agri-food system, leaving out other serious problems such as inequality, injustice, power, etc (see De Schutter, 2017, Fuchs et al., 2015, Allouche, 2011). When

the discourse of food security is such reductionist, it endorses neoliberal arguments of free market and technical revolution. However, as mentioned by Hopma & Woods (2014) technical solutions are not enough to solve agri-food problems, because the decisions to act are primarily political.

For a deeper understanding of a specific agri-food system, it is necessary to go beyond the focus on food production, taking into consideration the multi-functionality and multidimensionality of the agri-food system (IAASTD, 2009; Kamp et al., 2013; Loiseau at al., 2012, Marsden, 2013). In order to contribute to addressing the gap in knowledge of a broad perspective of agri-food systems, I developed a hierarchical indicator framework that assesses the current state of the Brazilian agri-food system adapting as a baseline the definition of agri-food system made by Ericksen (2008). The framework is a set of indicators that describe the quality of essential criteria to guarantee the well-functioning of the 3 outcomes of sustainability in agri-food systems: environmental quality, food security/sovereignty and human wellbeing. As exposed in chapter 2, food sovereignty is a politicised concept, compared to the depoliticised discourse of global food security (Hopma & Woods, 2014). It also differs from the discourse of national food security by empowering the people of the nation and farmers, instead of nation states, bringing elements of social justice. Adopting a broad perspective of the sustainability of agri-food systems, I keep the concept of food security within the framework, agreeing with Clapp (2014) that both food security and food sovereignty are complementary and useful concepts to address the challenges of global food system. The food security also incorporates the mainstream solutions of agri-food system problems about increasing food production, as well as environmental quality addresses the need of reducing impact (Godfray and Garnett 2014, Foley et al. 2009). Finally, well-being englobes many attributes of inequality, social injustice, cultural and economic impacts (De Schutter, 2017, Allouche, 2011, Jarosz, 2011). The framework integrates a broad perspective of sustainability, but also ensure policy relevance and applicability linking the assessment of indicators with goals and targets from international agreements, as required by Hanjra & Qureshi (2010).

According to Marsden (2013), new questions and visions about agri-food systems have risen from multiple stakeholders, a wider and more integrated set of security and sustainability, health and wellbeing. For a deeper understanding of the system and these new stakeholders' visions, I explore transition pathways (chapter 6) to achieve

sustainability in the Brazilian agri-food system for two normative future visions (chapter 5) in order to contribute to the advance of the literature in this area (section 7.3 and 7.4). The visions and pathways were built from the perspective and knowledge of a group of 31 stakeholders, using the sustainability concepts of the indicator framework, national policy and international agreements.

7. 3. Brazilian agri-food system context and pathways to improve its sustainability

I agree with many stakeholders who claimed that the Brazilian government has been a barrier to the improvement of a broad perspective of the sustainability of the Brazilian agri-food system. Moreover, probably the sustainability performance under the new federal government mandate starting from 2019 will be much worse than the previous ones (see trends below). The perspective of the Brazilian government is aligned with mainstream concerns and solutions for the development of the agri-food system (to increase production and reduce environmental impacts, see for example, Godfray and Garnett (2014), Foley et al. (2009) and reports from international agencies such as FAO (2017), IAASTD (2009), Foresight (2011), chapter 2. The vision of MAPA is to be recognised for quality and agility for implementing policies and providing services towards the sustainable development of agribusiness. This vision is aligned with food security discourse, which feeds into neoliberal arguments of the free market and a new technological revolution as a solution for agri-food system challenges (see (Jarosz, 2011). Overall, as shown in chapter 4, the results of these policies are the strengthening of access to food (such as hunger eradication), the quality of the Brazilian diet and the positive Brazilian balance of trade in food. On the other hand, they also increase challenges and problems related to over-extraction and degradation of natural resources, biodiversity conservation, ecosystem services provision, traditional communities' preservation, social equity and justice (see table 8, chapter 4). Like the mainstream solutions (see chapter 2), the Brazilian government massively relies on technical approaches to solve problems of the agri-food system. According to EMBRAPA's "vision 2014-2034", the future challenges should be tackled with

technologies that are more efficient to supply the food demand, fibre and energy for the industry of transformation and green chemistry, and surplus for exportation in order to guarantee global food and energy security (EMBRAPA, 2014). Based on this perspective, the government adopts very strong policies for the development of agribusiness mainly focused on large-scale farms for the exportation of low added-value products (see Ioris, 2017). This perspective aligns with the discourse of global food security (Hopma and Woods, 2014), presenting food security as a scientific problem rather than a political one. The Brazilian government also presents Brazil as the world's barn for the supply of food commodities, aggravating or not addressing broad sustainability issues for the Brazilian agri-food system, beyond the production of food (see De Schutter, 2017, Fuchs et al., 2015, Allouche, 2011, Hanjra & Qureshi, 2010 and Dupont & Thirlwell, 2009 chapter 4).

A new wave of ultra-neoliberalism started to be implemented by the current Brazilian government after the coup culminating in the illegal impeachment of President Dilma Rousseff in August 2016 (see FPA, 2017, Bastos, 2017, Villaverde, 2016, CNTE, 2016, Proner et al. 2016, Souza, 2016, Braz, 2016). One of the most significant changes for the Brazilian agri-food system is the eradication of the Ministry of Agrarian Development - MDA, which was converted to the Special Secretary for Family Farmer and Agricultural Development – SSFFAD. The dichotomy between MAPA (representing agribusiness for exports and large farmers) and MDA (representing sustainable agriculture and small-scale family farmers) was one of the most important discussions with stakeholders during the workshops and interviews. The majority of stakeholders highlighted that the excessive support and investment in agribusiness by the Brazilian government is detrimental to small-scale family farmers, is a central barrier to the improvement of the Brazilian agri-food system (see table 13, chapter 6). No stakeholder came close to imagining that an impeachment would take place in Brazil or such a radical reduction of support to small-scale family farmers, traditional communities, land reform and sustainable agriculture in general in such a short time. In fact, the sequence of four presidential mandates of the left wing (2003 – 2016) culminated in a gradual social advances and reduction of inequality in Brazil (Souza, 2016). As Sonnino et al. (2014) point out, CONSEA and the launch of the Zero Hunger program are part of a positive turning point on food security policies in Brazil in 2003. With an increasing investment in social policies (including the creation

of MDA), by 2014 Brazil was no longer on the UN hunger map (GGN, 2017a). Ninety NGOs and social movements signed a manifesto in May 2017 against the new wave of ultra-neoliberalism coming from the Brazilian government in partnership with the BBB lobby, which they claimed was violating human rights, promoting land tenure chaos and normalization of environmental crimes (GGN, 2017b). With the election of an ultra-right wing and ultra-neoliberal government in 2018 in Brazil, a broad or even minimum perspective of sustainability of the Brazilian agri-food system is under serious threat. For instance, some of the first actions of the new government were (see Folha, 2019, O Estado de Sao Paulo, 2019, GGN, 2019, GGN, 2019a, Guardian, 2019, Guardian, 2019a):

- The extinction of CONSEA. According to Sonnino et al. (2014), CONSEA was a central pillar to orient the creation and management of essential food security policies in Brazil, such as the LOSAN, Zero Hunger programme, PAA, PNAE. The authors consider CONSEA as a pioneer and successful example of reflexive governance (see chapter 2);

- Change the attribution of identification, delimitation and demarcation of indigenous land in the country from FUNAI to MAPA. MAPA represents the agribusiness interests, as mentioned by several stakeholders and Ioris (2017). The sector has been one of the main obstacles for the demarcation of indigenous land;

- The extinction of departments to deal with climate change and fight against deforestation from the Ministry of Environment. So far, there is no similar departments in any other Ministry. From August 2017 to July 2018, Brazil records worst annual deforestation for a decade (MMA, 2019). All expectations is that the new president will make current situation worse;

- A small reduction in the national minimum wage. During the campaign, the new President said that workers would have to choose between labour rights or jobs;

- The extinction of the Ministries of Labour, Culture and Cities, Sports and Racial integration;

In this context of problems and adverse political scenarios, I discuss the main challenges for implementing the two future visions for the improvement of the sustainability of the Brazilian agri-food system. Because the In-depth reform vision incorporates elements of food security discourse (see table 10 and 11, chapter 5 and appendix 7), its implementation would face less resistance than the Radical transformation vision. **The main mechanism** to implement In-depth reform, i.e. the transfer of technology aligns with the mainstream and Brazilian government perspectives (see appendix 7 and MAPA, 2017, EMBRAPA, 2014). The **top down approach** and the main **outcomes** i.e., the improvement of the supply chain of conventional and sustainable agriculture by better management practices, also resonates with the mainstream aims to increase food production and reduce environmental impacts (see FAO, 2017, Godfray & Garnett, 2014, Foresight, 2011, Foley et al., 2009, IAASTD, 2009). Another common point with the mainstream is the focus on reforms to improve sustainability of conventional agriculture, keeping sustainable agriculture as a desirable alternative niche, following the weak ecological modernization of Marsden (2013). According to Ioris, (2017), "the Brazilian experience illustrates how agro-neoliberalism flourishes in a context of market-centred solutions and regulatory flexibility, but also that it demands novel forms of government support and relies on some of the oldest political traditions (e.g. aggressive manipulation of party politics, lack of transparency, deceitful claims of progress and elements of racism). However, **the main positive aspect** of In-deep Reform execution is that the government holds the power of implementation, not necessarily depending on the mobilization of society. On the other hand, it is **unlikely** that the total implementation of the In-depth reform will occur in the short term, simply because the government (as a rule and not exception) is not an active agent for deep sustainable changes. As stated above and by stakeholders, the Brazilian government has been a barrier to the improvement of the broad sustainability of the Brazilian agri-food system. Actually, the new government presents itself as an aggressive agent to dismantle the recent small progresses on food security policies and sustainability. This poses a significant **limitation** and dilemma for the implementation of the vision, because the main actor responsible for change is also the main barrier to change. Another weakness of the vision, as well as of the food security discourse in general (see chapter 2), is the massive reliance on science and technological revolution to improve sustainability in the agri-food system, based on a narrow definition of

sustainability (see Hopma and Woods 2014). In short, the environmental aspects of the In-depth reform vision will be kept mainly depending on the success of pressures from international markets and agreements signed by Brazil and from social society mobilization.In contrast, the implementation of the Radical transformation vision would suffer strong resistance, because it incorporates elements of the food sovereignty discourse (see section 5. 3. 3 of chapter 5), which differs from mainstream solutions for the agri-food system and Brazilian central policies (see section 2. 3 of chapter 2). Social mobilization, social governance and education as **main mechanisms** for the implementation of the vision, are not common solutions in food security discourse (see Riol, 2017, Walsh-Diley et al, 2016, Hopma & Woods, 2014, De Schutter, 2014). Neither the **bottom up approach** nor 'local, sustainable and decentralized agriculture' as main **outcomes** of the vision are desirable solutions for the agri-food system mainstream perspective and Brazilian policies. **The main positive aspect** of Radical transformation is the broad sustainability aim to convert the entire Brazilian agri-food system into sustainable agriculture practiced by small-scale family farmers, medium-scale farmers and traditional communities. The establishment of a solid partnership between consumers and producers would deliver a system of balanced power relations and durable achievements, following the strong ecological modernization of Marsden (2013). However, the implementation of Radical transformation is very **unlikely** because it conflicts with the dominant agri-food regime in Brazil and radically contrasts with the sustainability trends from the new government; both described above (see also section 2.3 of chapter 2 and Ioris, 2017). It would face huge resistance from the Brazilian government and powerful groups like BBB. As pointed out by Geels (2011, p. 25), "it is therefore unlikely that environmental innovations will be able to replace existing systems without changes in economic frame conditions (e.g., taxes, subsidies, regulatory frameworks). These changes will require changes in policies, which entails politics and power struggles, because vested interests will try to resist such changes". Consequently, the implementation of the Radical transformation depends on some extent of government support or a very strong society mobilization to pressure for government support or reduce government retaliations. Therefore, two **limitations** for the implementation of the vision include the apathy of citizens to engage in a movement to change the current status quo and the lack of strategy to use public policy to promote changes. In addition, some critiques of food sovereignty discourse, like in Hopma and Woods (2014), also

weaken the implementation of the vision, such as the immense challenge to convert more than 95% of conventional production to sustainable agriculture in Brazil. It is also challenging to overcome the discourse of food as a commodity, to stop or reduce large-scale production for export, and deal with the economic consequences of reduction of the positive trade balance from food exports.

The two visions both have weaknesses and limitations of implementation, therefore a combination of both might increase the probability to improve the sustainability of the Brazilian agri-food system in a long-term.

7. 4. Recommendations for transition pathways for a sustainable Brazilian agri-food system

I called my recommendation for alternative transition pathways for the sustainability of the Brazilian agri-food system "In-depth transformation". Deep changes are necessary to overcome the urgent problems of the Brazilian agri-food system (see discussion of problems in chapters 4 and 6). Transition pathways towards sustainability would increase the probability of success if they approach both top down and bottom up possibilities of change. At least for Brazil, exclusive top down or bottom up approaches would not effectively make significant positive changes in the agri-food system. As mentioned by several stakeholders and explained in this chapter and chapter 2, the federal government has been one of the biggest barriers to the improvement of sustainability, i.e., a top down approach is not working. On the other hand, a bottom up approach does not have the power or engagement of society to implement significant changes. Social movements have to intensively pressure and monitor governments to promote changes. However, in contrast to the radical transformation vision or food sovereignty discourse, I also argue that it is also necessary to make alliance with governments. In the Brazilian case, a radical change is unlikely to occur due to the lack of power, protagonism and access to the ordinary people from the civil society. On the other hand, contrary to the In-depth reform vision or food security discourse, I propose an approach that prioritizes social justice, rights to food and to produce food, small-scale farmers, medium-scale farmers and traditional communities. In other words, I advocate an approach, which applies the discourse of

food sovereignty (Peoples' Food Sovereignty Statement, 2017), adding to it a broad perspective of sustainability of the agri-food system (presented in chapter 4) without denying the role of institutions and trade. In this transition, a real transformative pathway is need for the Brazilian agri-food system to move towards a strong ecological modernization of Marsden (2013). The pathways towards sustainability should be more effective with balanced and connected initiatives between society and government. This interaction is underexplored for both the In-depth reform and Radical transformation visions. However, as stated by Geels (2011), transitions are complex and long-term processes including the participation of multiple actors.

In figure 8 and Appendix 15, I present a synthesis of strategies and measures that I identify as the most promising to produce pathways to a more sustainable agri-food system. These results come from the analysis of the hierarchical indicator framework, stakeholders' perspectives and expertise, agri-food system discourses, international agreements, national policies, national and international agencies recommendations, the literature review and my own suggestions.

In figure 8, the circles represent the strategies. The arrows show the relationship of dependence between strategies. The size of the circle indicates the importance of the strategy. The blue circles are the most important and the catalyst points of the pathway. The black circles are intermediate strategies generated by the catalyst ones. The purples circles are the main mechanism of change. The green circles are the final strategies and the outcome points of the In-depth vision.
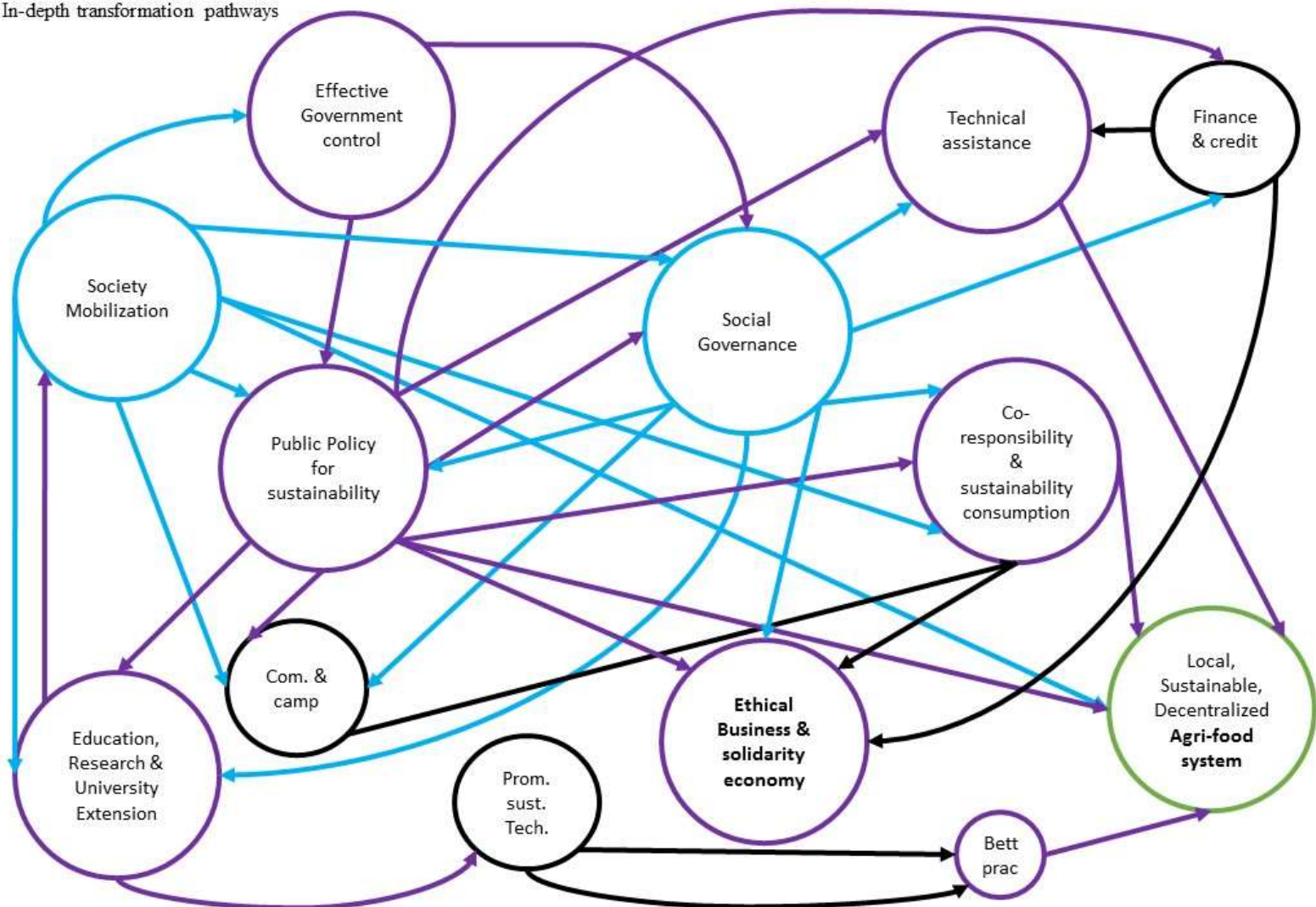
Figure 8. In-depth transformation transition pathways diagram

The catalyst for change comes prominently from the bottom up strategies, *society mobilization* and *social governance,* simultaneously engaging and being supported by the top down strategies, *public policy for sustainability* and *effective government control* (figure 8). Several strategies implemented in tandem would create an improvement of the sustainability of the Brazilian agri-food system through a gradual conversion of conventional agriculture towards sustainable agriculture, predominantly local and decentralised. These four strategies, started and led by the *society mobilization* strategy, are the core mechanisms of change for the In-depth transformation pathways. However, the beginning of the transformation requires a change in the structures of power, and *society mobilization* again is the most promising strategy to promote this change, because it is the unique mechanism to guarantee the maintenance of democracy and a transition to sustainability. Governments are always shifting the agenda according to the most powerful force (Campbell, 2009). Then, a central point (also a main challenge) for this change is the political engagement of the population. Today, citizens around the world do not feel represented by politicians and are unmotivated to act politically (Baumann and Mauro, 2016). Therefore, popular engagement in elections and in monitoring elected representatives is low. In Brazil, there is an initiative known as 'Democratic Coalition', which could improve this crucial issue. Democratic Coalition was developed by 101 civil society institutions, which consisted in a tentative to submit to the Lower House a popular bill. The project aims to deepen the process of democratization of political power in Brazil through a democratic political reform and clean election, with broad participation of civil society (Coalizão democrática, 2013). The success of such an initiative would bring more balance into the political power structure and offer the conditions to reshape national public policies and government control towards the sustainability of the agri-food system. In other words, with active *society mobilization*, a better executive government would be elected to rule that in turn would subordinate public policies to sustainability and give more space for society participation, enhancing *social governance.* The democratic coalition initiative was relaunched and gained strength in 2016 because of an intensification of discussions about the need for reforms in the national political system in Brazil.

With the core mechanism of change established, other strategies and measures could be generated or improved. Many other instruments or initiatives for change already exist, but need to be reinforced. Important initiatives to improve the agri-food system have evolved and grown, such as coalizão agricultura-pecuaria-floresta (agriculture-livestock-forest coalition), CSA movement, MST (Landless rural workers movement), in addition to a large variety of projects from universities, NGOs, cooperatives, etc. In appendix 15, I show some measures that could leverage the sustainability of the Brazilian agri-food system for the strategies presented in the figure 8. These strategies and measures come from or are adaptations of the measures from the In-depth reform and Radical transformations visions, plus a new strategy, *ethical business and solidarity economy* (figure 8, see definition in the chapter 2) and its related new measures (appendix 15). The highlight of the *ethical business and solidarity economy* strategy is the promotion and strengthening of cooperatives and social entrepreneurship, which may be a viable alternative to powerful traditional agribusiness companies.

Finally, a change in the structure of the Brazilian federal ministries is imperative for the transformation of the Brazilian agri-food system. Without a radical change in the Brazilian governmental structures and policies, it is only possible to produce reforms in the agri-food system to deliver weak levels of sustainability (or weak ecological modernization, as suggested by Marsden et al., 2013) as proposed by In-depth reform (chapters 5 and 6). As seen in chapter 2, the mission and vision of the defunct MDA presented a much broader perspective of sustainability than MAPA. They dealt with the key Brazilian challenges highlighted in this research, such as territorial management, access to land, productive inclusion, socio-economic and environmental development, food sovereignty and equity (MDA, 2016). For this reason, in the In-depth transformation transition pathways, the MDA would be re-established and institutionalized as the centre of planning, policymaking and action for the sustainability of the Brazilian agri-food system, merging MAPA and EMBRAPA into its structure. A few highlighted sustainability policies of the new MDA should be:

- Strengthen territorial planning and management, land reform, land tenure regularization through INCRA;

- Establish a policy to gradually transfer financial support for large farmer's agribusinesses from public to private sources, as proposed by OECD (2015). At the same time, to transfer public financial support to small-scale family farmers, medium-scale farmers and traditional communities under the condition that they implement sustainable agricultural practices;

- The gradual conversion of conventional to agroecological agriculture (organic, agroforestry, permaculture) through massive investment in technical assistance, based on research and technology outcomes from universities in partnership with farmers and traditional communities;

- Improve and intensively scale up government mechanisms to develop and support sustainable agriculture by small-scale family farmers and traditional communities, such as PNAE and PPA;

- Create mechanisms to develop the Brazilian agro-industry, adding value to the products for export and for the domestic market;

- Strengthen mechanisms of social governance such as ZEE, CONDRAF, PLANAPO, basin committees, law of cities, master plans, as well as incentives for the development of ethical business and sustainable consumption.

The In-depth transformation pathways would accumulate the strength, benefits and achievements of both visions, mainly because of the broad sustainability coming from the Radical transformation vision. However, as in the Radical transformation vision, the In-depth transformation pathways also would face strong resistance to implementation because of the radical changes proposed, which might be weakened by the lack of government support. In fact, with the election of the neoliberal and ultra-right wing government, it is unlikely that any one of the 3 pathways (In-depth reform, Radical transformation or In-depth transformation) towards sustainability be implemented. On the opposite side, it is expected a throwback in the food security and sustainability policies achieved in recent years. Some level of partnership between federal government and civil society towards social change took place in the "lulismo" period (see chapter 2) in Brazil. This period was marked by important social achievements, however this slow and gradual model of social change, characterized by class conciliation, represents a "weak reformism" (as described by Singer, 2012) rather than a real social transformation. Specifically for the agri-food system,

"lulismo" created and strengthened food security and sustainability policies, however, it could not make the transition from a weak to a strong ecological modernization (see Marsden, et al., 2013). "A strong ecological modernisation should ideally lead to a value place-based eco-economy, including agro-food networks, which are more embedded in local communities, based upon a more comprehensive science and knowledge base" (Horlings and Marsden, 2011, p. 445). Even performing moderate changes by a class conciliation approach, "lulismo" could not resist the 'vested interests' (see Geels, 2011) of the dominant regime. With the presidential impeachment or Brazilian parliamentary coup in 2016 (see chapter 2), the "lulismo's" conciliation period was broken and a new political phase has started with the election of an ultra-conservative government. "The outcomes of periods of struggle are often unexpected and perhaps less transformative than social movements hope" (Campbell, 2009, p.10). On the other hand, the author state that new social movements have never experienced more power over the design of food supply chains. All these movements worldwide have to address questions about power, complicity and commitment to egalitarianism (Patel, 2009). As mentioned by Schiavoni (2009) the best way to communicate the message of food sovereignty is by doing, by engaging citizens directly in food system transformation. Somehow, this is the same message of stakeholders about the need of a citizenship education and engagement. The MST has developed a vibrant rural political community, termed "agrarian citizenship" by Wittman (2009) , where the activist gain a diverse set of active political voices and socio-ecological practices that goes beyond settlement boundaries. For this reason and because it represents the more structured and organized resistance of food sovereignty movement in Brazil, MST were declared enemies and, alongside traditional/indigenous community movements, tend to be intensively pursued and criminalised by the new government. According to van der Ploeg (2008) there are several highly interesting expressions of the struggle for self-regulation in the world, including MST in Brazil (van der Ploeg, 2006), pointing towards radically improved farming practices. On the other hand, the authors considers the dominating social-technical regime the worst expressions of food insecurity and environmental degradation. "When citizens and consumers in general lose trust and realign (both symbolically and materially) with those farmers engaged in the struggle for self-regulation, far-reaching and massive transitions might well be possible" (Van der

Ploeg, 2006, p. 271). CONSEA, PAA, PNAE were pioneer examples of reflexive governance in Brazil (Sonnino et al. 2014). This process of moderate social improvements and participation was an exception period within the dominant regime of the Brazilian agri-food system. However, as mentioned by Campbell (2009), social movements have never experienced like currently, such influence on food supply chain. Then, despite of the trend of a period of throwbacks for the Brazilian agri-food system, it is important to see transition as a long-term process (Geels, 2011). It means that with the failure of the neoliberal model (Van der Ploeg. 2006), the seeds of reflexive governance sown in Brazil, probably will have a chance for a new resurgent period, and so on. In my perspective, any possibility of transformation towards a sustainable agri-food system in Brazil has to include and indeed be led by a bottom-up approach. Consequently, in order to develop transition pathways towards a real transformation, it is essential that future and current social movements continue to drive forward and make significant advances in their missions and aims.

8

Conclusion

In this chapter, I summarize the key findings of my thesis and their contribution to the literature. I made significant contributions to the areas of (1) the definition and conceptualisation of agri-food systems and their sustainability; (2) the development of an indicator framework for assessing the multi-faceted aspects of agri-food system sustainability; and (3) guidance for systemic change based on participatory and bottom-up approaches. Below, I go through each of these in turn.

1. Broader understanding and definition of agri-food system and its sustainability

Current studies lack a clear and broad definition of the concept of agri-food systems and their sustainability, applicability and connections with policy instruments. These studies have focused on narrow sustainability aspects of agricultural production, environmental and technical issues, strongly neglecting the entire structure of agri-food systems (Binder et al. 2010, Heller and Keoleian, 2003). In order to contribute to fill this gap identified in the literature, I provide a conceptual model of agri-food system (figure 2, chapter 3), adapted from Ericksen (2008). Therefore, I define agri-food systems as all interactions involving the activities from production through to consumption of food, from field to table, including fibre and biofuels; the stakeholders involved, and the outcomes of these activities that influence the status of human wellbeing, food security/food sovereignty and environmental quality (adapted from Heller and Keoleian, 2003; Ericksen, 2008; IAASTD, 2009). This concept incorporates the two central points for sustainability advocated in this research. First, it embraces the multi-functionality and multidimensionality aspects (see literature review in chapter 2), both essential elements for the sustainability of the agri-food system. Finally, it is policy relevant, once it is recognized and incorporated into the UN policies and agreements such as MDGs, SDGs, Aichi targets, MA, IAASTD, FAO and consequently into national and local policies.

2. A hierarchical indicator framework to assess sustainability of agri-food systems

There is a lack of policy relevant and applicable instruments to deal with the complexity and challenges around understanding and improving sustainability of agri-food systems. With the continuous use of these dominant frameworks and the development of products/process centred in technological, environmental and best practice means (Binder et al. 2010, Heller and Keoleian, 2003), the agri-food regime keeps a transition to a weak ecological modernization (Marsden et al. 2013). In order to contribute to fill the gap of the lack of an applicable and policy relevant tool to address and monitor the sustainability of agri-food systems, I develop the hierarchical indicator framework. The hierarchical indicator framework is a set of indicators that describe the quality of essential criteria to guarantee the well-functioning of the 3 outcomes of sustainability in agri-food systems: environmental quality, food security/sovereignty and human wellbeing. I ensure the policy relevance of the tool by linking the assessment of indicators with goals and targets from international agreements. The tool is flexible to include or exclude indicators or policy instruments depending on the task established. The indicator framework can be an alternative tool to link knowledge and practice, enhancing communicability and partnerships for governance, using an objective to be reached and a clear concept definition (key finding one). The quality of indicators can be improved, updated and monitored.

A very important contribution of the key findings 1 and 2 relates to the inconsistency and narrowness of mainstream food security discourses, rendering it insufficient for the challenges of a broad concept of sustainability of agri-food systems. I demonstrate this by the analysis of literature review (chapter 2).and by the application of the hierarchical indicator framework in the Brazilian agri-food system (chapter 4).

3. Bottom up and participatory approach aiming system change

Although constantly neglected by mainstream approaches, there has been a growing focus on bottom-up approaches led by end-users, consumers and citizens aimed at a systemic change (Quist, 2013). Sonnino et al. (2016) argues that this new emphasis on more integrated place-based and reflexive governance is important to solve the profound food security vulnerabilities. Participatory approaches can be an opportunity to incorporate food sovereignty to the solutions of the agri-food system challenges, once it is both a concept and a bottom-up movement. Food sovereignty aims for a transformation in the global agri-food system, in terms of equity, social justice, democracy, right to food, ecological sustainability (Riol, 2017; Hopma & Woods, 2014). Participatory approaches are promising mechanisms to more effectively assess agri-food systems, produce insights and induce pathways towards sustainability (Quist et. al., 2013), since the selection of sustainability indicators is essentially a political process (Rudd, 2004; McCool & Stankey, 2004). Adapting the participatory backcasting approach (Quist, 2013; Quist et al., 2013 and Quist, 2016), I contribute with the development of the bottom-up and participatory research using and linking mixed methods to draw up transition pathways for a sustainable Brazilian agri-food system (figure 1, chapter 3).

According to Ioris (2015), a critical examination of the achievements, justification and failures of agroneoliberalism is still missing in most available publications. Indeed, it is a big challenge to build such critique to a very complex subject in a broad, robust, policy relevant, multidisciplinary and applicable manner. Developing a framework to deal with this challenge was a central concern, aim and probably the main contribution of my thesis to the specific theme. The use of mixed methods approach through the combination of quantitative and qualitative approaches provides condition for a more complete understanding of the research problem within a pragmatic philosophical worldview (or paradigm, see Cresswell, 2014). Pragmatists concern with applications and solutions to problem (Patton, 1990) and use pluralistic approaches to understand the problem (Patton, 1990, Morgan, 2007, Tashakkori & Teddlie, 2010). In order to formulate and discuss transition pathways for a sustainable Brazilian agri-food system, I use a participatory backcasting framework as an umbrella approach supported by

content analysis (see figure 1, chapter 3). The methodology generates a deep understanding of the agri-food system and its sustainability, discourses and challenges through the problem orientation step (both quantitative and qualitative research, chapters 2 and 4). With this baseline, in a participatory process was possible to generate two future visions (qualitative research, chapter 5) and then build pathways towards its sustainability with the lenses of sustainable transition theories (qualitative research, chapter 6).

A limitation of research in agri-food systems is the overemphasis on environmental impacts, technical approaches and productivity (see chapter 2 and 4). The focus of the debate on the solution of these issues prevents a broader understanding of the agri-food systems. This focus restricts the dialogue to a technical and environmental debate, when in reality the most promising solutions orbit in the political sphere. This research goes beyond these issues by including social and economic aspects; however, political aspects are included only by the use of literature review. For the refinement of this aspect and next steps for this research, I recommend the inclusion of a new criterion of governance in the hierarchical indicator framework (see chapter 4). As seen in chapter 2, concentration of power for the dominant food regime is one of the most (maybe the most) important elements that prevents significant sustainability improvement in the Brazilian agri-food system. A possible refinement for this research is the understanding of mechanisms of power and strategies to overcome it. Therefore, similarly to governance, it would be interesting to include a new criterion of power into the hierarchical indicator framework as a next step of the research, using the methodology of manifestations of power developed by Fuchs et al. (2015). In appendix 16, I present a preliminary list of manifestations of power for the Brazilian agri-food system following the cited methodology. Brazil is a big and heterogeneous country. The adoption of a national scale in this research culminates in generalization and loss of information. However, the results of this research are relevant to orient national strategies for the sustainability of the Brazilian agri-food system by government and general stakeholders. On the other hand, the government applies the same national policy in the whole country and the federal government is very concentrated in power.

To some extent, this research registers and analyses an important period of the Brazilian agri-food system history under the lenses of sustainable transition theories. The dominant food regime is part of a new political force that took the power and start

to impose hard and drastic retaliation in response to a short and moderate period of progress in food nutrition and security and people's rights. Improvements to this research could be done in different temporal and spatial scales, including the recommendations cited above, in order to understand, register and offer alternatives to avoid the dramatic throwbacks and challenges faced by the Brazilian agri-food system.

A real transformation towards a broad sustainability of the agri-food system would come from, or at least strongly would include, a bottom up approach coming from different manifestations of reflexive governance by society mobilization. According to Riol (2017) food sovereignty was founded within civil society. Carrigan (2014) states that civil society is essential to ensure that nation states provide the rights to adequate food and that those rights are not co-opted by the interests of corporations. Woods (2008) draws attention to the prominent role of social movements in rural politics and social action, highlighting their capacity to produce social and political transformations, actively engage in the process of re-making rural society, community development projects, cooperatives and marketing initiatives, purchase land and training and education programmes. There are many social movements and initiatives going in this direction, however, because there is no strong connection or common agenda among them, it is unlikely that such a transformation will become true in the short or medium term globally. On the other hand, following this trend, the MST (Landless rural workers' movement, associated to Via Campesina) is investing in a strategy of winning the support of the urban and rural population for its cause. They are promoting their claims for sustainable production and social justice in sustainable food and culture fairs, as well as social media, demonstrations, publications, developing agroindustry and cooperatives (MST, 2017). For this reason, MST and traditional communities social movements are considered enemies to be destroyed by the dominant food regime and will suffer a strong retaliation by the new government. Following De Schutter (2014) for a democratic food system to become the mainstream, people need to own their food system. The success of rural and urban social movements worldwide is crucial to move in this direction. Brazil is a huge laboratory and all its current struggles reported by this research will influence new trends in the agri-food system worldwide.

Through my research, in drawing attention to the multifaceted aspects of sustainable agri-food systems, their empirical measurement, and bottom-up participatory processes in eliciting more sustainable pathways, I believe I have contributed to inform this struggle, no matter how remote the prospect of sustainable transformation now seems.

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Appendices

Appendix 1. List of indicators from the hierarchical indicator framework

Tim	ID	Criteria	Indicator	Sources	Unit	Recommendation	Policy Relevance	Target/Limits	Level of compliance /fulfillment	Performance
Human wellbeing Food Security	1	Equity/Social Welfare	Target 1.C: 1.8 Prevalence of underweight children under-five years of age	IPEA, (2014)	%	Corbiere-Nicollier, (2011) MDG	MDG Goal 1: Eradicate extreme poverty and hunger Target 1.C	Target 1.C: Halve, between 1990 and 2015, the proportion of people who suffer from hunger	Target 1.C: Complied, between 1989 and 2006, reduction from 7.1 to 1.8% (1/4) the indicator 1.8. Below 2.3% is considered eradicated.	High Improvement
Human wellbeing Food Security	2	Equity/Social Welfare	Target 1.C: 1.9 Proportion of population below minimum level of dietary energy consumption		%	Corbiere-Nicollier, (2011)	MDG Goal 1: Eradicate extreme poverty and hunger Target 1.C	Target 1.C: Halve, between 1990 and 2015, the proportion of people who suffer from hunger	Target 1.C: Complied for the indicator 1.9, from 2005 it has been <5%, considered the FAO target.	High Improvement
Human wellbeing	3	Equity/Social Welfare	2.1 Net enrolment ratio in primary education	IPEA, (2014)	%	MDG	MDG Goal 2: Achieve universal primary education Target 2.A	Target 2.A: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	MDG: Target 2. A (2.1) Complied to Brazil, from 81.2 to 97.7% 1990 - 2012. In this level the target is considered achieved; Rural: 66.9% to 96.37%; Urban: 87.4% to 97.1%.	High Improvement
Human wellbeing	4	Equity/Social Welfare	2. 3 Literacy rate of 15-24 year-old, women and men	IPEA, (2014)	%	MDG	MDG Goal 2: Achieve universal primary education Target 2.A	Target 2.A: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	(2.3). (1990 to 2012) - Complied, from 90.3 to 98.6% in Brazil; rural 78.3 to 96.3%, urban 94.5 to 99 %.	High Improvement
Human wellbeing Food Security	5	Equity/Social Welfare	Target 1.A 1.1 Proportion of population below $1 (PPP) per day	IPEA, (2014)	%	Corbiere-Nicollier, (2011) MDG	MDG Goal 1: Eradicate extreme poverty and hunger Target 1.A	Target 1.A Specific targets for Brazil: 1.A: Reduce to a 1/4, between 1990 and 2015, the proportion of people whose income is less than one dollar a day	Target 1.A: Complied, reduction to less than 1/7 the 1990 level in 2012 (25.5% to 3.5%); Rural (51.2 to 8.9%)	Some Improvement
Human wellbeing Food Security	6	Equity/Social Welfare	Target 1.B: 1.6 Proportion of employed people living below $1 (PPP) per day	IPEA, (2014)	%	Corbiere-Nicollier, (2011) MDG	MDG Goal 1: Eradicate extreme poverty and hunger Target 1.B	Target 1.B: Achieve full and productive employment and decent work for all, including women and young people	Target 1.B: From 1992 to 2012: Almost complied, general reduction from 15.2 to 1.3%; rural (36.3 to 6.6 %), urban (8.5 to 0.4 %); male (15.1 to 1.4 %), female (15.2 to 1.2 %);	Some Improvement
Human wellbeing	7	Equity/Social Welfare	2.2 Proportion of pupils starting grade 1 who reach last grade of primary	IPEA, (2014)	%	MDG	MDG Goal 2: Achieve universal primary education Target 2.A	Target 2.A: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	(2.2), Highly improved, but not complied, 79.6% of students studying at the suitable grade;	Some Improvement
Human wellbeing	8	Equity/Social Welfare	2. 3a Proportion of population within 15-24 year-old,	IPEA, (2014)	%	MDG	MDG Goal 2: Achieve universal	Target 2.A: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	(2.3). (1990 to 2012) - Not Complied, from 59.9 to 84 % in Brazil; rural 29.9 to 70.8 %, urban 70.2 to 86.1	Some Improvement

			with at least primary school					primary education Target 2.A	%, male 56.3 to 80.8 %, female 63.4 to 87.3 %, white 69.1 to 89.9 %, Black 49.2 to 79.6 %;	
Human wellbeing	9	Equity/Social Welfare	2. 3b Proportion of population within 15-24 year-old, with at least high school	IPEA, (2014)	%	MDG	**MDG** Goal 2: Achieve universal primary education Target 2.A	Target 2.A: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling	(2.3). (1990 to 2012) - Not Complied, from 33.6 to 76.8 % in Brazil; rural 11.8 to 59.6 %, urban 41.1 to 79.4 %, male 30 to 72.3 %, female 37.1 to 81.4 %, white 42.9 to 84.6 %, Black 22.8 to 70.7 %;	Some Improvement
Human wellbeing	10	Equity/Social Welfare	3.1 Ratios of girls to boys in primary, secondary and tertiary education	IPEA, (2014)	ratio number girls/num ber boys	MDG	**MDG** Goal 3: Promote gender equality and empower women Target 3.A	Target 3.A: Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015	Target 3. A 3. 1. Complied since 1990, 1.03 to 1.0, 1990-2012 for primary education. However, the inequality is against men for the secondary (1.25) and tertiary education (1.36).	Some Improvement
Human wellbeing	11	Equity/Social Welfare	3.2 Share of women in wage employment in the non-agricultural sector	IPEA, (2014)	%	MDG	**MDG** Goal 3: Promote gender equality and empower women Target 3.A	Target 3.A: Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2016	3. 2. Almost complied, from 42.7 to 47.3% 1990-2012. However, when compared only employees with university diploma, women were 59.5% of total (2012);	Some Improvement
Human wellbeing	12	Equity/Social Welfare	7.8 Proportion of population using an improved drinking water source T14. Trends in proportion of the population using improved water services	IPEA, (2014)	%	MDG	**MDG** Goal 7: Ensure environmental sustainability Target 7.C	Target 7.C: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation	MDG Target 7.C: 7.8. Almost complied: From 70.1% (1990) to 85.5% (2012). Reduction from 29.9 to 14.5%. Urban areas from 89.6% to 93.4% and Rural areas from 15.9% to 35.1%.	Some Improvement
Human wellbeing	13	Equity/Social Welfare	7.9 Proportion of population using an improved sanitation facility	IPEA, (2014)	%	MDG	**MDG**Goal 7: Ensure environmental sustainability Target 7.C	Target 7.C: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation	MDG Target 7.C:7.9. Complied: From 53% (1990) to 77% (2012). Reduction from 47% to 23%. Urban areas (83.8%) and Rural areas (33.6%).	Some Improvement
Human wellbeing	14	Equity/Social Welfare	Target 1.A: 1.3 Share of poorest quintile in national consumption	IPEA, (2014)	%	Corbiere-Nicollier, (2011) MDG	MDG Goal 1: Eradicate extreme poverty and hunger Target 1.A	Target 1.A: Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day	MDG Goal 1. Share of poorest quintile in national consumption: 2,2% (1990) to 3.4% (2012);	No Improvement
Human wellbeing	15	Equity/Social Welfare	Target 1.A: 1.3a Share of richest quintile in national consumption	IPEA, (2014)	%	Corbiere-Nicollier, (2011) MDG	MDG Goal 1: Eradicate extreme poverty and hunger Target 1.A	Target 1.A: Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day	MDG Goal 1. Share of richest quintile in national consumption: 65.2% (1990) to 57.1% (2012);	No Improvement
Human wellbeing	16	Equity/Social Welfare	Target 1.A: 1.3b Gini Index	IPEA, (2014)	Gini Index	Corbiere-Nicollier, (2011) MDG	MDG Goal 1: Eradicate extreme poverty and hunger Target 1.A	Target 1.A: Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day	MDG Goal 1. Gini Index: 0.612 (1990) to 0.526 (2012);	No Improvement
Human wellbeing	17	Equity/Social Welfare	1. 4 Growth rate of GDP per person employed	IPEA, (2014)	Brazilian currency Reais (R$) and %	MDG	MDG Goal 1: Eradicate extreme poverty and hunger Target 1.B	Target 1.B: Achieve full and productive employment and decent work for all, including women and young people	MDG Goal 1. In 1995, the growth rate of GDP per person employed was R$ 40.592,12; In 2012, the growth rate of GDP per person employed was R$ 46.965,26; 1995-2012, the average growth 1995-2012 was 0,9%/year.	No Improvement

Human wellbeing	18	Equity/Social Welfare	Target 1.B: 1.5 Employment-to-population ratio (%)	IPEA, (2014)	%	Corbiere-Nicollier, (2011) MDG	MDG Goal 1: Eradicate extreme poverty and hunger Target 1.B	Target 1.B: Achieve full and productive employment and decent work for all, including women and young people	Target 1.B: From 1992 to 2012: Not complied, general reduction of 2.4 % (64.1 to 61.7%); rural (76.8 to 65.1 %), urban (60.8 to 61.2%); male (80.8 to 74.1 %), female (48.4 to 50.3 %)(IPEA, 2014); IBGE (2012) - Family farms: 74.4% of employed people (12.3 million, 2.6 per farm), Non family farms: 25.6% of employed people (4.2 million);	No Improvement
Human wellbeing Food Security	19	Equity/Social Welfare	Target 1.B: 1.7 Proportion of own-account and contributing family workers in total employment	IPEA, (2014)	%	Corbiere-Nicollier, (2011) MDG	MDG Goal 1: Eradicate extreme poverty and hunger Target 1.B	Target 1.B: Achieve full and productive employment and decent work for all, including women and young people	Target 1.B: From 1992 to 2012: Non Complied??, general reduction from 30.9 to 21.1 %; rural (61.4 to 50 %), urban (21 to 16.6 %); male (27.8 to 22.4 %), female (35.6 to 19.5 %);	No Improvement
Human wellbeing	20	Equity/Social Welfare	3.3 Proportion of seats held by women in national parliament	IPEA, (2014)	%	MDG	**MDG** Goal 3: Promote gender equality and empower women Target 3.A	Target 3.A: Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2017	3. 3. Not complied, 11.9% Mayor, 13.3% vereadores (2012). Camara dos Deputados 9%, Senate 14.8%.	No Improvement
Human wellbeing Food Security	21	Equity/Social Welfare	Land distribution for agriculture use T18. Trends in land-use change and land tenure in the traditional territories of indigenous and local communities Allocation and tenure of land	IBGE, (2012) FAOStat, (2017)	number of farms, hectares and %	Corbiere-Nicollier, (2011) Gabrielle (2014)	**Aichi Targets** Strategic goal E. Enhance implementation through participatory planning, knowledge management and capacity-building	Target 18: By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels	Aichi Targets T18. IBGE (2012). Family farms: 84.4% of the number of farms in Brazil (4 367 902), 24.3 % of the total area (80.25 million ha), average size 18.37 ha; Non family farms: 15.6 % of the number of farms, 75.7 of the total area, average size of 309.18 ha (MDA, 2009)	No Improvement
Human wellbeing	22	Equity/Social Welfare	Slavery work	IBGE (2012) FAOStat, (2017)	number of slavery workers	Corbiere-Nicollier, (2011) Gabrielle (2014)	**MDG** Goal 1: Eradicate extreme poverty and hunger Target 1.B	Target 1.B: Achieve full and productive employment and decent work for all, including women and young people	MDG Goal 1. Slavery work: 93% of the released slavery workers came from rural areas (2003 to 2012), and 70% of the cases in 2012; (1986 - 2012) CPT registered 165.808 enounces about cases of slavery workers, 2.952 in 2012. released 44.425 slavery workers, 2.750 in 2012 from 1995 to 2012; MTE, (2012)	No Improvement
Human wellbeing Food Security	23	Equity/Social Welfare	share of dietary energy supply derived from cereals, roots and tubers	FAOStat, (2017)	percentage	Authors	**MDG** Goal 1: Eradicate extreme poverty and hunger Target 1.C	Target 1.C: Halve, between 1990 and 2015, the proportion of people who suffer from hunger	37% to 34% from 2006 to 2011	No Improvement
Human wellbeing Food Security	24	Equity/Social Welfare	Average protein supply (g/capita/day) (3-year average)	FAOStat, (2017)	g/capita/day	Authors	**MDG** Goal 1: Eradicate extreme poverty and hunger Target 1.C	Target 1.C: Halve, between 1990 and 2015, the proportion of people who suffer from hunger	84 to 92	Some Improvement

Human wellbeing Food Security	25	Equity/Social Welfare	Average supply of protein of animal origin (g/capita/day) (3-year average)	FAOStat, (2017)	g/capita/day	Authors	**MDG** Goal 1: Eradicate extreme poverty and hunger Target 1.C	Target 1.C: Halve, between 1990 and 2015, the proportion of people who suffer from hunger	42 to 49	Some Improvement
Human wellbeing	26	Economic stability/ Investment	Agriculture Trade Balance	MDA, (2009) MAPA, (2015)	%	Authors	N. A.	N. A.	MDA, (2009) - Trade balance (balanca comercial - 1995- 2006): Exportation: 13.8 to 36.9 billions of dollars; Inportation: 6.5 to 4.5 billions of dollars; Trade balance: 7.3 to 32.6 billions of dollars (4.5 times); Percentage of total Brazilian exportation from agribusiness: 28.7 to 26.8 % and Importation 12.5 to 4.9 %; Mapa, 2015 - Total exportation: 2015 - 46,2%, 2014 - 43%, 2013 - 41,3%, 2012 - 39.5%, 2011 - 37.1%, 2010 - 37.9%;	High Improvement
Human wellbeing	27	Economic stability/ Investment	Agriculture % of the total GDP	MDA, (2009) CEPEA/USP (2015)	%	Authors	N. A.	N. A.	MDA, (2009) - GDP: 705.6 Billion of reais to 2.369 trillion (1995 - 2006); GDP per capita increased from 4.8 to 5.9 thousands of dollar, same period; Agribusiness - 35.6 to 111.2 billions of reais same period. Agribusiness share of GDP - 5.8 to 5.5 %, same period; World Bank, 2017 - Primary agriculture was 5.3% of GDP in 2012; CEPEA/USP, 2016 - agribusiness supply chain was 22.54% of the Brazilian GDP in 2013	Some Improvement
Human wellbeing	28	Economic stability/ Investment	Top commodities production	FAOStat, (2017)	Int $1000/ Production (MT)	Authors	N. A.	N. A.	FAOStat, (2017): Production (Int $1000)/Production (MT) Meat indigenous, catle - 25392834 / 9399963 Sugar cane - 23454723 / 721077287 Soybeans - 17787070 / 65848857 Meat indigenous, chicken - 16506226 / 11588139 Milk, whole fresh cow - 9980095 / 32304421 Meat indigenous, pig - 5326872 / 3465216 Oranges - 3481071 / 18012560 Coffee, green - 3263405 / 3037534 Rice, paddy - 3167672 / 11549881 Maize - 2971352 / 71072810	No Improvement
Human wellbeing	29	Economic stability/ Investment	Value of food imports over total merchandise exports (%) (3-year average)	FAOStat, (2017)	%	Authors	N. A.	N. A.	FAOStat, (2017) - 2 (2006) to 3 (2011)	No Improvement
Human wellbeing	30	Economic stability/ Investment	Percentage of paved roads over total roads (%)	FAOStat, (2017)	%	Authors	N. A.	N. A.	FAOStat, (2017) - 12.2 (2006) to 13.5 (2011)	No Improvement

Human wellbeing	31	Economic stability/ Investment	Road density (per 100 square km of land area)	FAOStat, (2017)	per 100 sq km	Authors	N. A.	N. A.	FAOStat, (2017) - 18.9 (2006) to 18.6 (2011)	No Improvement
Human wellbeing	32	Economic stability/ Investment	Rail-lines density (per 100 square km of land area)	FAOStat, (2017)	per 100 sq km	Authors	N. A.	N. A.	FAOStat, (2017) - 0.3 (2006) to 0.4 (2011)	No Improvement
Human wellbeing	33	Culture/ Tradition	**T18. Trends in degree to which traditional knowledge and practices are respected through: full integration, participation and safeguards in national implementation of the Strategic Plan** T16. Number of Parties to the Nagoya Protocol that have legislative, administrative or policy measures and institutional	IUCN (2011)	NA	IUCN (2011)	**Aichi Targets** T18. Traditional knowledge respected T16. The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization	Aichi Targets T18. By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels. T16. Nagoya Protocol in force and operational By 2020, A. ratified and operationalized B. Developed, promulgated and regulated;	At Least 231 indigenous peoples in Brasil, population of 600 thousand people; Plus, a imense variety of several other traditional communities such as, quilombolas, seringueiros, fundo de pasto, faxinais, ribeirinhos, geraizeiros, romani, pomeranos, quebradeiras de coco babaçu, caiçaras, entre outros. T16. A. The implementation of The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization: Current situation: signed; B. Novo marco legal brasileiro seguindo as diretrizes do Protocolo de Nagoya; Current Situation: -	No Improvement
Human wellbeing	34	Culture/ Tradition	T18. Trends of linguistic diversity and numbers of speakers of indigenous languages	IUCN (2011)	Number of languages and speakers	IUCN (2011)	**Aichi Targets** T18. Traditional knowledge respected	Aichi Targets T18. Idem indicator 26	T18. Trends of linguistic diversity and numbers of speakers of indigenous languages: Estimated 1000 languages and dialects before European arrived. Currently, there are 231 indigenous peoples in Brazil, around 600 thousand people. More than 180 languages and dialects spoken (Brasil/MMA, 2010)	No Improvement
Food security	35	Culture/ Tradition	T13. Trends in genetic diversity of cultivated plants, and farmed and domesticated animals and their wild relatives; Diversity of crops	IUCN (2011) FAOStat, (2017)	Number of species	IUCN (2011)	Aichi Target T13. By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable pecies, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity	By 2020, Double the number of species	Number of species and varieties in national germplasm bank: 668 (IUCN, 2011) Number of traditional vegetal varieties (IUCN, 2011) -- still no database % Area harvested (Selected commodities below cover 90.98 % of the total area harvested; 71.88 % only with soybean, maize and sugar cane) : Soybeans - 36.73 Maize - 20.88 Sugar cane - 14.27 Beans dry - 3.98 Rice paddy - 3.55 Coffee green - 3.12 Wheat - 2.81 Cassava - 2.49 Seed cotton - 2.03 Cashew nuts with shell - 1.11	No Improvement

Environmental quality	36	Culture/ Tradition	T7. Trends in area of forest, agricultural and aquaculture ecosystems under sustainable management	IUCN (2011)	Area (ha) and %	IUCN (2011)	**Aichi Targets** T7. By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.	Aichi Targets T7. By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity	Aichi Targets T7. Agricultural area organic total (1000 ha): 517 (2006), 932.12 (2009), 687.04 (2011); % Agricultural area organic total (1000 ha): 0.33 (2006), 0.65 (2009), No data (2011); Agricultural land (1000 ha): 272784 (2006), 273540 (2009), 275373 (2011). From Calculated % Agricultural area organic total (1000 ha): 0.19 (2006), 0.34 (2009), 0.25 (2011);	No Improvement
Environmental quality	37	Ecosystem services/ Biodiversity Conservation	MDG 7. 1. Proportion of land area covered by forest Aichi Targets T5. Trends in extent of selected biomes, ecosystems and habitats Deforestation	IPEA, (2014) IUCN (2011) MMA (2017) Santos et al., (2007)	% forest cover/ remnant	MDG Aichi targets	MDG Goal 7: Ensure environmental sustainability Aichi Targets T5. Habitat loss is at least halved	MDG Goal 7: Ensure environmental sustainability Target 7.A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources Target 7.B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss Aichi Targets T5. Habitat loss is at least halved By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced	FAOStat, (2017), table database 1996 - 66%; 2001 - 64%; 2006 - 62%; 2011 - 61%; MMA, (2017): Remnant vegetation per Biome: Caatinga: 53.38% (until 2009); Cerrado: 51.16% (until 2009); Mata Atlantica: 22.25% (until 2008), Pampa: 36.06% (until 2008); Pantanal: 83.14% (until 2008), Amazonia: 86.74% (until 2007, Santos, et al. 2007) Aichi Targets T5. Legal Amazon Deforestation: -18% (2014-2013), -83% (2013-2004); (INPE, 2017)	Some Improvement
Environmental quality	38	Ecosystem services/ Biodiversity Conservation	MDG 7.4 Proportion of fish stocks within safe biological limits Aichi Targets T6. Trends in extinction risk of target and bycatch aquatic species T6. Trends in fishing effort capacity	IPEA, (2014) IUCN (2011)	%	MDG Aichi targets	MDG Goal 7: Ensure environmental sustainability Aichi targets T6. Sustainable management of marine living resources	MDG Goal 7: Ensure environmental sustainability Target 7.A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources Target 7.B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss Aichi Target T6. Sustainable management of marine living resources By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits	From 153 stocks analyzed 11% non-exploited, 4% underexploited, 23% fully exploited, 33% overexploited, 29% need more studies; National list of species overexploited or threatened to overexploitation: 11 invertebrate species and 39 fishes (IPEA, 2014)	No Improvement
Environmental quality	39	Ecosystem services/ Biodiversity Conservation	MDG 7.6 Proportion of terrestrial and marine areas protected Aichi Tagets T11. Trends in extent of marine	IPEA, (2014) IUCN (2011)	%	MDG Aichi targets	MDG Goal 7: Ensure environmental sustainability Aichi targets T11. Protected areas increased and improved	MDG Goal 7: Ensure environmental sustainability Target 7.A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources Target 7.B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss	7.6. Protected areas: 2000 - 916 Units/0.7 million Km2 to 1783 Units/1.5 million km2. Sustainable Use - 1224 units/1 million km2; and Integral Protection - 559 units/520 000 km2. Conservation Units are 17% of the continental area and 1.5% marine areas; However, only the Amazon biome is covered with more then 17% of its area within Protected areas, as recommended by IUCN, (2011) (26,2%: IP - 9.4%,	No Improvement

			protected areas, coverage of key biodiversity areas and management effectiveness; T11. Trends in representative coverage of protected areas and other area based approaches, including sites of particular importance for biodiversity, and of terrestrial, marine and inland water systems					Aichi Target T11. By 2020, at least 17 % of terrestrial and inland water areas and 10 % of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape	SU - 16.5%, IP+SU - 0.3%). The others are covered by Atlantic Forest (8.9%: IP - 1.9%, SU - 6.5%, IP+SU - 0.5%), Cerrado (8.2%: PI - 2.9%, SU - 5.2%, PI+SU - 0.2%), Caatinga (7.4%: IP - 1.1%, US - 6.3%), Pantanal (4.6%: IP - 2.9%, SU - 1.7%), Pampa (2.7%: IP - 0.3%, SU - 2.4%); T11. Área protegida de cada bioma com unidades de conservação do SNUC (%) : Amazônia 27,10%; Cerrado 8,43%; Mata Atlântica 8,99%; Caatinga 7,33%; Pampa 3,50%; Pantanal 4,79%; Zona Costeira e Marinha* 3,15% UCs com Efetividade da Gestão Média ou Superior (%) = 69% (Meta = 100%) UCs com instrumentos legais assinados com residentes/usuários = 20% (Meta = 100%) Áreas protegidas integradas com gestão biorregional (partes de reservas da biosfera e/ou mosaicos - %) = 14% (Meta= 30%)	
Environm ental quality	40	Ecosystem services/ Biodiversity Conservation	MDG 7.7 Proportion of species threatened with extinction Aichi Targets T12. Trends in extinction risk of species	IPEA, (2014) IUCN (2011)	number of endanger ed species	Corbiere-Nicollier, (2011) Verburg, (2014) MDG Aichi targets	MDG Goal 7: Ensure environmental sustainability Aichi Target T12. Extinction prevented	MDG Goal 7: Ensure environmental sustainability Target 7.A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources Target 7.B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss Aichi Target T12. By 2020, the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained	7.7. Brazil: 1.4 to 2.4 million of species, the biggest biodiversity in the world, 10 to 20% of known and catalogued species. Species threatened with extinction: 472 flora, 627 fauna. Mil especies extintas anualmente? IUCN (2011)	No Improvement
Environm ental quality	41	Ecosystem services/ Biodiversity Conservation	T14. Population trends and extinction risk trends of species that provide ecosystem services T14. Trends in benefits that humans derive from selected ecosystem services. (Degraded area in ecosystems providers of essential services, ex.: Permanent Preservation Area);	IUCN (2011)	% of degraded areas	MDG Aichi targets	T14. Ecosystems and essential services safeguarded	Aichi Target T14. By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable	T14. Degraded area in ecosystems providers of essential services, ex.: Permanent Preservation Area - 44 million Ha, 43% of total APPs (Sparovek et al. 2011)	No Improvement

Environmental quality	42	Ecosystem services/ Biodiversity Conservation	Vegetation rate, area of natural vegetation; T15. Status and trends in extent and condition of habitats that provide carbon storage T15. Trends in proportion of degraded/threatened habitats	Sparovek et al. (2011)	million ha	Verburg, (2014) MDG Aichi targets	Aichi Targets T15. Ecosystems restored and resilience enhanced	Aichi Targets T15. By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks have been enhanced, through conservation and restoration, including restoration of at least 15 % of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification	T15. According Sparovek et al 2011, the total area of degraded ecosystems to be restored was 87 million Ha. Consequently, the target is to reduce to 74 million degraded areas by 2020 (15%); Atlantic Forest 76 million Ha degraded (64.6 by 2020); Amazon 17 (14 by 2020); Cerrado 48 (41 by 2020); Caatinga 45 (39 by 2020); Pantanal 15 (13 by 2020); Pampa 54 (46 by 2020).	No Improvement
Environmental quality	43	Use of resources/ Pollution	MDG 7. 2. Total CO2 emissions	IPEA, (2014)	tonnes CO2eq over the life cycle	Corbiere-Nicollier, (2011) Verburg, (2014)	MDG Goal 7: Ensure environmental sustainability	MDG Goal 7: Ensure environmental sustainability Target 7.A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources	MDG Target 7. A 7. 2. Total: 2 billion tonnes of CO2eq (2005) to 1.3 Billion CO2eq (2010), 38,7% reduction; Agriculture and Cattle Ranching: 2005 - 78% of CO2 emissions. Direct 20%, indirect 58% (land use change); 2010 - 57% of CO2 emissions. Direct 35%, indirect 32% (land use change);	Some Improvement
Environmental quality	44	Use of resources/ Pollution	MDG 7. 2. CO2 emissions per capita	IPEA, (2014)	tonnes CO2eq over the life cycle	Corbiere-Nicollier, (2011) Verburg, (2014)	MDG Goal 7: Ensure environmental sustainability	MDG Goal 7: Ensure environmental sustainability Target 7.A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources	MDG Target 7. A 7. 2. Per capita: 11 tonnes of CO2 (2005) to 6.6 tonnes (2010);	Some Improvement
Environmental quality	45	Use of resources/ Pollution	MDG 7. 2. CO2 emissions per $1 GDP (PPP)	IPEA, (2014)	tonnes CO2eq over the life cycle	Corbiere-Nicollier, (2011) Verburg, (2014)	MDG Goal 7: Ensure environmental sustainability	MDG Goal 7: Ensure environmental sustainability Target 7.A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources	MDG Target 7. A 7. 2. Per 1$ GDP (PPP): 1.5 kg (2005) to 0.7 (2010)	Some Improvement
Environmental quality	46	Use of resources/ Pollution	Aichi Targets T8. Trends in water quality in aquatic ecosystems: % Percentual das classes de IET dos pontos de amostragem em corpos d'água lóticos não considerados super eutróficos ou hipereutróficos	IUCN (2011)	%	Corbiere-Nicollier, (2011) Aichi Targets	Aichi Targets T8. Pollution reduced	By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity. CDB Target 2020 = 95% (IUCN, 2011)	78%	No Improvement
Environmental quality	47	Use of resources/ Pollution	T8. Trends in water quality in aquatic ecosystems: % Percentual das classes de IET dos pontos de	IUCN (2011)	%	Corbiere-Nicollier, (2011) Aichi Targets	Aichi Targets T8. Pollution reduced	By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity. CDB Target 2020 = 95% (IUCN, 2011)	60%	No Improvement

			amostragem em corpos d'água lênticos não considerados super eutróficos ou hipereutróficos							
Environmental quality	48	Use of resources/ Pollution	T8. Trends in water quality in aquatic ecosystems: % dos pontos avaliados com qualidade das águas ótima ou boa (IQA/ANA)	IUCN (2011)	%	Aichi Targets	Aichi Targets T8. Pollution reduced	By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity. CDB Target 2020 = 95% (IUCN, 2011)	80%	No Improvement
Environmental quality	49	Use of resources/ Pollution	MDG 7.5 Proportion of total water resources used	IPEA, (2014)	%	Corbiere-Nicollier, (2011) Dantsis et al. (2010)	MDG Goal 7: Ensure environmental sustainability	MDG Goal 7: Ensure environmental sustainability Target 7.A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources	MDG Target 7.A: 7.5. Water balance 2010: Availability/Demand for water resources (water flow/withdrawal): the situation was excellent for 70% of the analysed area, 7% confortable, 6% alarming, 4% critical, 13% very critical;	No Improvement
Environmental quality Food Security	50	Use of resources/ Pollution	Aichi Targets T4. Ecological limits assessed in terms of sustainable production and consumption Use of fertilizers: **Total quantity of nitrogen (N), phosphorus (P)** and potassium (K) applied per unit of agricultural land area (kg ha 1)	FAOStat, (2017)	tonnes of nutrients per 1000Ha; consumption of tonnes of nutrients	Dantsis et al. (2010)	Aichi Targets T4. Sustainable consumption and production	Aichi Targets T4. By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits	Aichi Targets T4. Nitrogen Fertilizers (N total nutrients) tonnes of nutrients per 1000Ha: 26.64 (2002), 29.36 (2006), 36.87 (2010); Phosphate Fertilizers (P205 total nutrients) tonnes of nutrients per 1000Ha: 38.26 (2002), 40.21 (2006), 43.72 (2010); Fertilizers (K20 total nutrients) consumption of tonnes of nutrients: 2962910 (2002), 3429560 (2006), 4600680 (2012); FAOStat, (2017)	No Improvement
Environmental quality Food Security	51	Use of resources/ Pollution	Aichi Targets T4. Ecological limits assessed in terms of sustainable production and consumption Use of pesticides: Total quantity of pesticides applied per unit of agricultural land area (kg ha 1) T8.	FAOStat, (2017)	tonnes per 1000 Ha	Dantsis et al. (2010) ABRASCO (2014)	**Aichi Targets** T4. Sustainable consumption and production	Aichi Targets T4. By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits	Aichi Targets T4. Pesticides tonnes per 1000 Ha: 0.35 (1991), 0.73 (1996), 1.15 (2001); T4. Agrochemicals use from 10.5 liters per hectare (l / ha) in 2002 to 12.0 l / ha in 2011	No Improvement

Appendix 2. Interview guide (70 - 75 minutes)

Part A – General questions
Presentation of the aims of the project and the concept of agri-food system and what I am considering sustainability (human well-being, food security and environmental quality)
A. 1. Taking into account the whole agri-food system presented, please, could you tell me very briefly, which is the main problem of the Brazilian agri-food system?
A. 2. In short words, what is necessary/missing for the improvement of the sustainability of the Brazilian agri-food system?
A. 3. Are your personal goals the same ones of your institution/sector? If not, what are the differences?
Part B – Specific questions
Presentation of the problems and strengths of Brazilian agri-food system based on the literature review and results found on chapter 3.
Presentation of the goals and targets of the international agreements to achieve agri-food system sustainability.
B. 1. Do you think that your organization fit to these goals to achieve the international agreements for sustainability? Which ones?
B. 2. Do you think that the international agreements are important to promote sustainability of the agri-food systems? Are they effective? If not, which are the alternatives or how to improve them?
Presentation of the objectives and instruments of the national policy for the Brazilian agri-food system.
B. 3. Do you think that the national policy is suitable and will accomplish with the goals and targets of the international agreements to achieve sustainability of the agri-food system?
B. 4. What changes are needed to bring about the sustainability of the Brazilian agri-food system? Please, talk about structural/institutional changes (B4a), cultural and behavioural changes (B4b), and technological changes (B4c). (How and Who for each change)
B. 5. Do you think that these changes will happen or not? What is the role of the technology in this process? Are you optimist or pessimist about the technology role?
B. 6. What is the role of the citizens?
B. 7. What is (are) the mechanism (s) to make the necessary changes to improve the sustainability of the agri-food system? In other words: Why are they not happening? What is missing? Is it a new insight, connection, strategy or mechanism? Could you describe it?
B. 8. Which are the opportunities and barriers for the proposed changes?
B. 9. Who could or should contribute to realizing these changes and what activities should they do?
B. 10. Who would oppose the required changes and how this opposition be dealt with?
B. 11. Does your participation bring something new for you? Have you had new insights or perspectives about the subject?

Appendix 3. Figure presented to stakeholders' during fieldwork

The project aim
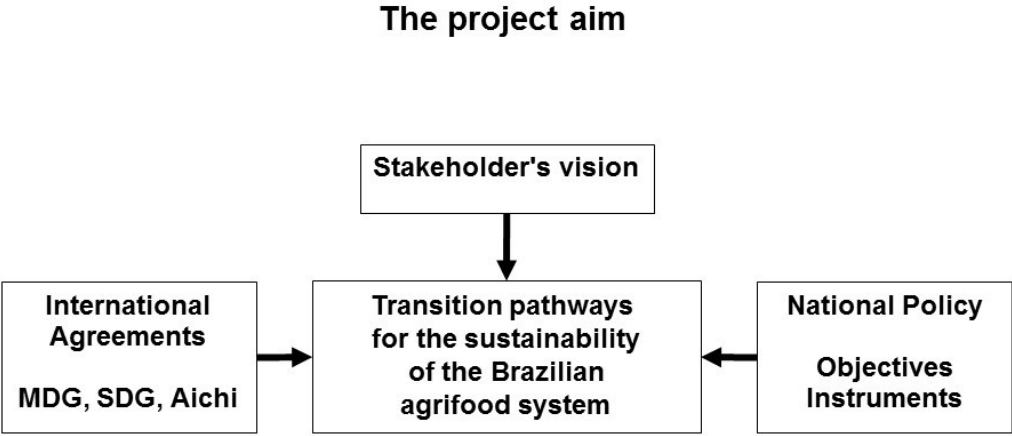
Appendix 4. Concepts of agri-food system and its sustainability used during fieldwork
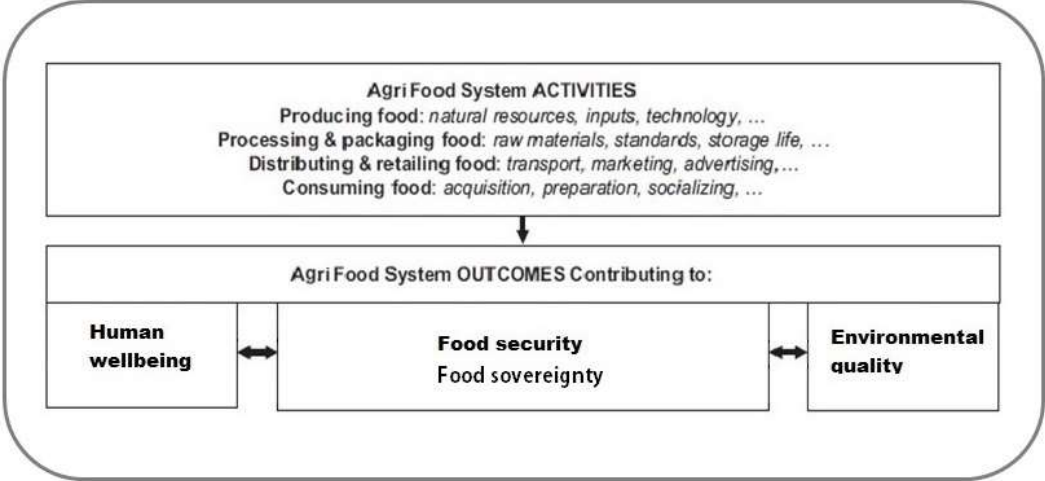
Appendix 5. Photo from the Future visions' workshop, Brasilia, DF, Brazil

Appendix 6. Narratives created based on the transcription of the interviews

A1. Problem

A1. Taking into account the whole agri-food system presented, please, could you tell me very briefly, what are the main problems of the Brazilian agri-food system?

A1. 1. Social inequality

The current system concentrates land, income and capital, which generates huge social inequalities. The concentration of land and income, social deprivation and poor human health were the elements most mentioned by stakeholders. The system currently maintains a high level of social deprivation, inhibiting access to the means of production, providing low incomes that hinder access to healthy food and decent living conditions. This concentration of power produces extreme scenes of violence and murders due to land disputes, mainly threatening traditional peoples and small-scale family farmers resulting in an exodus from rural areas and the creation of urban slums. Overall, the system does not bring equal benefits to the whole of society.

A1. 2. Low level of development and investment in logistic infrastructure

The low level of development and investment in infrastructure is considered to be an important factor which negatively affects the competitiveness of Brazilian agriculture. Railways and waterways are scarce in the country, leaving road transport as the only option, which is more expensive.

A1. 3. External subsidies

Another vulnerable element of the conventional agri-food system is its high dependency on natural and financial inputs and subsidies. This high dependency on external inputs makes the conventional system vulnerable to changes in the economy and increases pressure on natural resources, leaving the conventional system more unsustainable over time, and more dependent on increasingly scarce resources.

A1. 4. Loss of traditional rural culture

One main feature mentioned is the loss of traditional rural culture. This loss directly relates to the concentration of land and expulsion of small-scale family farmers and traditional communities from rural areas, threats to their quality of life, security and survival. This element also highlights the current loss in the variety and quality of food produced and consumed by these groups, directly influencing the impoverishment of the population's diet.

A1. 5. Strong degradation of ecosystem services

Another element stated by stakeholders is the strong degradation of ecosystem services.

A1. 6. Intensive use of agrochemicals

One important element considered negative is the intensive use of agrochemicals. For some, the simple use of agrochemicals by conventional agriculture is already something reprehensible. The use of agrochemicals and the intensive use of inputs and energy lead to the environmental degradation of the system, affecting soil, water and animal ethics. Another critical element is the large amount of waste in production, distribution and consumption of food.

A1. 7a. Lack of population's awareness and knowledge

The lack of population's awareness was one of the most highlighted elements as a problem for the unsustainability of the agri-food system. Some people stated that the main responsibility for the continued unsustainability of the current agri-food system is the lack of population's awareness . Some stakeholders relate the lack of awareness to the absence of a more formal knowledge, lack of adequate citizenship education (i.e. assume duties and responsibilities for a common wellbeing, how to live and develop society). Other stakeholders relate the lack of population awareness about sustainability in food production and consumption to the lack of information in agri-food system issues. Some consider that there is media blindness on the subject. Consequently, people are unable to visualize the integration of all aspect of the agri-food system.

A1. 7b. Lack of farmer's awareness and knowledge

Another element cited several times by stakeholders was the lack of farmer's knowledge about the agricultural system, as well as lack of information and technical assistance. According to several stakeholders, the obstacle for the improvement of the Brazilian agriculture and its sustainability is not the development of new sustainable technology. Brazil has good expertise in this area. The main issue is the inequality and inefficiency of transferring the existent technology.

A1. 8. Hegemony of the commoditization, exportation and low added-value system

One of the most stated elements of the unsustainability of Brazilian agri-food system is the hegemony of commoditization, exportation and low added-value model for agricultural products. According to stakeholders, this model is strengthened by a market that promotes unsustainable products. One of the consequences of this hegemony is the disparity between the benefits and allowances received by small-scale family farmers versus agribusiness.

A1. 9. Lack of control, inspection and regularization

The lack of control, inspection and regularization of the Brazilian agri-food system hinders the improvement of its sustainability. The main factor cited is the lack of land regularization, mentioned by many as a priority and urgent measure to be addressed. This lack of control worsens because Brazilian institutions are extremely bureaucratic, with lack of operational, managerial capacity and lack of commitment of civil servants. Other aggravating factors are the difficulty or impossibility to account for externalities of the production process within agro-food system and the absence of specific legislation for agroecology, which would give regulatory mechanisms for food production. The lack of flexibility in the Brazilian legislation also was mentioned as a barrier to the management of natural resources.

A1. 10. Lack of interest of the government to change the situation because of their corruption and economic benefits with the current situation, coupled with the lack of pressure from population

A large and hegemonic lobby is installed to expand the model of conventional agriculture, based on strong economic interests and a powerful political influence, sometimes supported by corrupt schemes. Consequently, there is a vested interest in government structures to maintain the current situation. With the exception of a few social movements, there is a general lack of interest of the population, which does not

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pressure the government to changes the system and does not create any stimulus for a transition towards sustainability.

A1. 11. Disproportion in public support to large farmers of conventional production versus small and medium farmers

One of the pillars of unsustainability of large farmers in the conventional system is their dependency on economic subsidies and intensive credit support. On the other hand, small-scale family farmers have great difficulty accessing credit and socio-environmental aid. However, according to some stakeholders the medium scale farmer is the least assisted among rural producers.

A1. 12. Farmers and consumers disconnection

The disconnection between farmers and consumers, between the city and rural areas, is a strong negative factor, which makes the food production system unsustainable.

A.13. Lack of knowledge of the interaction between problems

There is also a lack of knowledge and understanding on how different problems of the agri-food system interact and affect each other. Therefore, it is difficult to provide effective solutions for these problems.

A2. Solution

A2. In short, what is necessary/missing for the improvement of the sustainability of the Brazilian agri-food system?

A2. 1. Policies to reduce social inequality

The three main policies mentioned by stakeholders that need to be strengthened to improve equity and social welfare are land access and distribution through land reform, improvements in the quality of education and distribution of income.

A2. 2. Investment in infrastructure and logistics

For the economic development and competitiveness of Brazilian agriculture, it is essential to invest improving logistics, mainly transportation and storage of products. Transportation logistics should be changed from the road network to a multi modal network favoring the railway and waterway systems.

A2. 3. Improve the management of natural resources

The improvement of natural resource management in food production with a central focus on the control of agrochemicals. Management has to be concentrated on the vision of an integrated system, soil and water management, and connection to the local agri-food system.

A2. 4. Massive investment for transferring social and sustainable technologies through technical assistance

There is almost a consensus among stakeholders that Brazil is successful in development technologies for agriculture. However, there is a barrier for accessing these technologies mainly for small-scale family farmers. Extending the knowledge of farmers is essential to improve the sustainability of the agri-food system. Therefore, intensive action by government is necessary to ensure access to technologies, through the massive investment in technical assistance.

A2. 5. Facilitate access to public financing for small-scale family farmers and medium farmers, binding it to sustainability standards through the support of technical assistance

Government needs to act intensively to facilitate farmer's access to credit, especially small-scale family farmers and medium farmers. The funding must be linked to sustainability standards, long-term planning, access to land and technical assistance. In addition, incentives to production should account for the social and environmental externalities from the entire production chain.

A2. 6. Firmer action by government in controlling the production process

Government must act more firmly in controlling the productive process, increase monitoring of the use of agrochemicals and natural resources and promote land regularization. The government must require social and environmental compliance, especially by large farmers.

A2. 7a. Conversion and adaptation of public policies for sustainability and conservation of ecosystem services

The government should adapt all public policies to comply with sustainability and conservation of ecosystem services. These policies should be decentralized and focused on territory, subnational and municipal levels.

A2. 7b. Task force for diagnosis and proposition of policies

There is a suggestion for government to create a task force to make a diagnosis and propose policies for the management of the food production system. Other suggestions propose working with the climate issue in a governmental proposal, and leverage the payment for environmental services (highly mentioned), carbon credit and ensure the variety of agricultural products.

A2. 8. Society awareness to generate transition towards sustainability

According to stakeholders, it is necessary to create awareness in all sectors of society, a true 'cultural revolution' where everyone would realize the benefits of sustainability and be motivated to make a transition and of accounting the externalities of the production system. In this viewpoint of radical change, the entire capitalist system would be changed, bringing a perspective of solidarity economy, reducing power of multinationals and market.

A2. 9. Create more space, policies and investment to promote local and sustainable agriculture

Create more space (improve social governance), policies and investment to promote local and sustainable agriculture, agro-ecological systems, and small-scale family farmers. Value the local and territory approach, e.g. decentralizing governmental planning and management of the agri-food system. Improve the market system for sustainable agriculture in municipalities, states and federal spheres, such as the PPA

(Governmental Food Acquisition Program) and the PNAE (National School Feeding Program). Change and adapt university courses to become focused on teaching and promoting sustainable agriculture.

A2. 10. Develop co-responsibility between farmers and consumers for sustainability

Develop co-responsibility between urban and rural areas, and unite farmers and consumers to promote sustainability. Consumers should demand sustainable practices along the chain, valuing and buying food directly from farmers.

A3. Personal Goals

Are your personal goals the same ones of your institution/sector? If not, what are the differences?

The vast majority of actors consider that the goals of the institution where they work are the same as theirs. In other words, they can identify their own personal objectives as part of the institution where they work. It expresses optimism and feelings that they are doing something to change the system. Only two interviewees from the government believe that the main institutional and their own objectives are not the same. However, they continue working there because they believe that they can influence a transition towards better objectives working for some internal initiatives.

B1. Institutional alignment

B. 1. Do you think that your organization fits to these goals to achieve the international agreements for sustainability?

Only two stakeholders do not think that their institution entirely fits to the goals from the international agreements. One said, "more than 80% of the institution's work aligned to agribusiness, the very unsustainable system". Another one stated, "the institution is minimally guided by the principles of sustainability. It has to improve it".

On the other hand, the latter one believes that the institution is on the path to change and be more coherent. Both stakeholders work for a governmental institution central to the Brazilian agri-food system.

Some of the institutions where some stakeholders work respond to a development agenda aligned to agribusiness, based on economic growth. However, usually there are small departments or specific projects within the institutions that cover more holistic sustainability concepts. Some of the stakeholders work in these alternatives spaces and try to make them grow and become the mainstream. Other stakeholders do believe that their institutions or professional activities are aligned with international agreements.

B2. Institutional agreements

B. 2. Do you think that the international agreements are important to promote sustainability of agri-food systems?

The majority of the participants (almost consensus) believe that the agreements are important because they are educational references, create a space for discussion, can guide national public policies, serve as a justification to open new spaces for sustainable projects into the institutions and/or create a moral obligation for governments to achieve sustainability. However, participants do not believe that the international agreements are effective. They are only volunteer schemes, have no connection with the ordinary citizen, there is no empowerment mechanisms for the population, work as a minimum denominator of consensus, not turn into laws and do not guarantee the slightest compliance. In addition, they can serve as a space for a hypocritical demagoguery of speech without effective transformation, are unjust between developed and underdevelopment countries and are a very slow process.

B3. National policy alignment

B. 3. Do you think that the national policy is suitable and will meet the goals and targets of the international agreements to achieve sustainability of the agri-food system?

In general, stakeholder's critique of the agri-food system national policy is strong and negative. Most stakeholders believe that the national policy for the agri-food system is not properly aligned with the sustainability principles agreed by Brazil in international agreements. It is mistaken, lacks focus, vision or a more objective planning strategy. It is far from enough and far from being efficient, not complying with visions that it would have to be based on. The policies for the small-scale family farmers bring just a few elements of sustainability, while policies for agribusiness bring even less or practically nothing. Some specific opinions that support this conclusion are:

The perverse subsidy policy favours the maintenance of asymmetries. The government is subsidizing all the inequality and the entire environmental cost;

It does not have an industrial mechanism to add value to the products of small or large farmers;

It is focused on technologies from the point of view of the capital and not from social technologies (see appendix 1) that could bring better incomes and conditions for the small farmer to remain in rural areas;

There are big deficiencies in regulation and in the implementation of policies. The government do not prioritize and invest in the environmental quality of the system;

There is no intention to solve conflicts of land tenure;

The national policy aims at increasing production for exportation (e.g. prioritizing soybean exportation), serving a very conservative and strong sector in the National Congress (called: ruralistas, bancada do boi or BBB, Cow, Bullet and Bible). It has serious social and environmental negative repercussions, affecting small-scale family farming to the viability of society and not making good use of the potentialities of the country.

Rural credit volume is not sufficient to meet the demand of farmers, which impacts the competitiveness of the Brazilian agriculture against European and USA agriculture. The finance goes mainly to large farmers without requirements for sustainability production. There are only crumbs left for small-scale family farmers and traditional communities, and are very bureaucratic to access. Some stakeholders advocate that credit should be fully restructured and be directed foremost to the small-scale family farming.

It has contradictory policies, for example:

- economic incentive policy for herbicide in contrast with the PRONARA (national program for the reduction of pesticide use).
- The PLANAPO (National Plan for Agroecology and Organic Production) that should be a central element of agri-food policy is only a proposal, while there is hegemony of agribusiness, which prevents PLANAPO's development. On the contrary, the country is facing an increase of transgenic crops, use of agrochemicals, etc;
- There is a divergence between participants in relation to the dualism in the Brazilian agri-food policy. All participants recognize that there is a dichotomy in relation to family agriculture of small farmers, represented by policies of Ministry of Agrarian Development (MDA) and agri-business, represented by policies of Ministry of Agriculture, Livestock and Food Supply (MAPA). Some consider that it would be better to have a unit that could see all groups of interest as part of a complex system and see how they complement each other instead of separating them. On the other hand, some stakeholders see a positive point to the division in agri-food politics, because the specific program for family agriculture favours a lot the small-scale family farmers. Others consider that there is a positive intention to the division, but that is not effective, since the MDA also develops the line of agribusiness, aiming to transform the small-scale farmer in a "little agribusiness". In fact, there are only few public calls to promote or apply agroecology, when in fact it should be the basis of all the technical assistance. A further consequence of this duality between large and small farmers is the lack of government policies to the medium farmers, abandoned by the Brazilian public policy.

- Some stakeholders draw the attention that MAPA and MDA do not incorporate the environmental agenda, which is task of the Ministry of Environment (MMA). These spheres do not talk with each other. Some people claim that the national policy is inadequate to achieve the objectives of sustainability because each Ministry has a different goal, besides the weight of public budget is heavily allocated on MAPA.

Participants mentioned a number of elements, which should be improved in national politics. Government is already deploying some of them:

The technical assistance is the critical element for the sustainability of the agri-food system. The Brazilian research in agriculture and forest area is excellent. New technologies of harvesting have been successfully developed, such as no-tillage farming, for example. However, in practice, these technologies are not transferred to the farmers.

There has been a significant improvement in the policies for the small-scale family farmers, however these policies in general should be working better. For example, why does PAA have to be 30% and not 100%? According to some participant's opinion, government should guarantee market (school lunches, hospitals, public kindergartens and other governmental destinations) for small-scale family farmers, who should concentrate their activities in improvement the sustainability of food production.

Several stakeholders advocate that credit and technical assistance must go through a transformation. It is necessary to support models that are more sustainable and not the conventional package ones. Some of them add that the resource provided must not be based on the size of the farmer, small or large, but on the purpose of a clear policy, offering cheaper money to produce more efficiently and more sustainably, differently from the current practice.

One option mentioned is the environmental service payment. However, there are no instruments to certificate the system or to guarantee a premium to the farmers that apply better agricultural practices. The ABC (Low Carbon Agriculture) plan has a minimum amount of resource, for example. A stakeholder stated that a

policy that rewards good decisions rather than fining or punishing is the best way to promote a transition.

Brazil needs to solve some chronic problems including inequality, poverty in rural areas, concentration of land, so it makes sense also have agricultural policies, considering the territory. Government must make a decent land reform, for example.

Consumers must have the information to make decisions on what is the impact of their choices. The consumer responsibility is completely absent in the Brazilian agri-food system.

It is lacking policies for big farmers improving performance in sustainability, even if they continue to produce conventionally, they can produce more sustainably.

Government has created spaces for popular participation, for example the National Commission of Agroecology and Organic Production that it is a committee created to look after PLANAPO (National Plan for Agroecology and Organic Production). The commission is consisted by half government and half civil society, and it is a space to build public policy. The initiative is a demand from the civil society during the Marcha das Margaridas (daisies' march, a demonstration performed by women's farmer);

There are public policies that still provide only crumbs to promote small-scale sustainable farming, however they are very interesting. For example, the national policy for ATER (Technical Assistance and Rural Extension) provides a technical assistance focused on Agroecology, which is developed by the PNATER (National Policy for Technical Assistance and Rural Extension). There are few calls on PLANAPO to leverage these agroecology projects through networks.

An alternative way to influence public policy is to use the market and multi-stakeholder initiatives to force the government to promote social benefits on policies, such as Coalizao Brasil – Clima, Florestas e Agricultura.

Some stakeholders recognize that in the last ten years, government had priority to address issues of the national feed and nutrition.

Appendix 7. Detailed perspective of the future visions

Future vision I – In-depth reform

<u>Detailed perspective</u>

Equity & social welfare

Brazilian society would have access to adequate and healthy food (table 10). There would be full social and productive inclusion in the agriculture system (table 10) to reduce social inequality (A2. 1). Government would promote land reform; however, it would not establish limits for land property (A1. 1). There would be a new balance to equalize public support to small-scale, medium and large farmers (A1. 11) and power among stakeholders (B3). Currently, national policies mostly cater to a very strong sector in the National Congress (BBB) (B3). Massive investment would be made to transfer social and more sustainable technologies through technical assistance, based on better management practices (A2. 4). One of the main strategies would be stakeholders' initiatives from the market pressuring government to promote social benefits by implementing new policies (B3). A central idea and strategy for both visions would be the promotion of a high quality education for the population (formal and informal) (A2. 1). A crucial element for both visions that requires changes in policies and society behaviour is education for sustainability (formal and informal). The majority of stakeholders mentioned education for citizenship as the central point for a transition towards sustainability.

Economic stability & investment

Economic development is one of the main strategies to bring sustainability to the agri-food system in this vision. Economic incentives would be applied to farmers, which adopt sustainable practices (C from Consensual idea, table 10). The incentives would come from payment for ecosystem services mechanisms (PES), for example. Investments in infrastructure are essential to facilitate the flow of products, mainly big ports, railways and waterways to promote agribusiness for exports (A1. 2). It is necessary to lower the cost of transport to improve Brazilian competitiveness on the international market.

Culture & tradition preservation

Access to healthy food and ways of production through social inclusion and economic development are strong pillars of the vision (A1. 4). Therefore, it is expected that the provision of qualified technical assistance to all and a focus on sustainability would bring better conditions of life to traditional communities as well. The assistance has to be permanent and contextualized when is applied to family agriculture (table 10, C). Heirloom seeds would be valued and preserved, as an example (table 10, C).

Ecosystem services maintenance & biodiversity conservation

Ecosystem services maintenance and biodiversity conservation are key elements to improve the sustainability of the Brazilian agri-food system. These improvements would be promoted by the adoption of better management practices, considering landscape context (table 10, C), the multi-use of agriculture (table 10, C) and conservation of natural resources (forest, water, soils, climate, etc) (table 10, C).

Use of natural resources and pollution

In this vision, the use of better management practices on agriculture and cattle ranching is the central strategy to improve the management of natural resources and for the sustainability of the Brazilian agri-food system. Some practices mentioned by stakeholders, that suit both visions are (C):

- wide adoption of low carbon emission agriculture
- optimization of land use by avoiding new deforestation
- supply green belts (referring to the production areas surrounding cities)
- expand the adoption of integrated management of pests and diseases (reduction in the use of pesticides)
- a preponderance of integrated production systems
- efficient system reducing waste
- highly efficiency in the use of natural resources
- sustainable technology

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- water and soil conservation

Some specific improved management practice elements for the In-depth reform vision are:

Public credit and technical assistance would be part of the same package and would be addressed to all farmers irrespective of their size, however with the condition of applying better management practices (B3) as a sustainability standard (A2. 5). Credit needs some improvement, but it is reasonably settled in Brazil. Technical assistance is the obstacle. Technologies are not adequately transferred to farmers. Farmers have to be trained to develop skills to conquer markets (B3)

Better management practices, control and monitoring are essential strategies for this vision (however, how much agrochemical is allowed is not clear) (A1. 6). Firmer action by government in controlling the production process is a high priority and main strategy (A2. 6). There is a consensus that the lack of control, inspection and regularization is a big problem in the system. This is the main mechanism of change for the vision (A1. 9)

There would be a high priority to improve regulation and implementation of policies, mainly a top down approach (B3). The controlled use of external subsidies into the system would be permitted (A1. 3). Certification schemes would be important mechanisms to apply better practices (A2. 3). Better practices would be used to avoid the current strong degradation of ecosystem services (A1. 5).

Governance: policy

Some necessary changes in national policy that suit both visions are:

- enhance the sustainability issue in irrigation law. Improve the legal framework to conserve water resources

- environmental (RL** and APP***) and land regularization

- adapt the legal framework to family farming and extractivism

- create laws that encourage sustainable practices and do not bring difficulties or coercion for food production and consumption, or environmental conservation;

Some changes in the national policy specific for the In-depth reform vision are:

National policy for the agri-food system needs several and significant changes towards sustainability. There would be an appropriate labelling of GMOs (table 10). Balance in the governmental support given to conventional agriculture and sustainable small-scale family farmer agriculture (A1. 8)

Conversion and adaptation of policies for sustainability and conservation of ecosystem services is very important and also it counts with market mechanisms (e.g. payment for ecosystem services) to be implemented (A2. 7)

It is important to create more space, policies and investment to promote local and sustainable agriculture, however not excluding investment in conventional and large agriculture (with the support of better management practices) (A2. 9)

It is important to support agribusiness, policies for exportation, use of agrochemical and GMOs. However, it is necessary to improve management practices and sustainability for all these policies (B3)

Develop an industrial mechanism to add value to the products of small or large farmers (B3)

Establishment of a premium price or payment for environmental services to farmers applying better agricultural practices, and use of certificate schemes (B3)

Agricultural policies taking into account territory and participatory process (B3)

Strength PLANAPO to promote agroecology and organic agriculture as an alternative strategy, however this is not a central idea for the vision (B3)

Governance: behaviour

Some stakeholders' consensus ideas about necessary changes in Brazilian behaviour that can suit both visions are:

- reduce the consumption of beef
- encourage society to reflect on sustainable consumption
- education for consumption (e.g. packaging, harvests, local production, reduce meat consumption)
- Change Brazilian style of food consumption
- consumers aware of their choices

Some ideas about changes in the Brazilian behaviour, specific for the In-depth reform vision are:

Population awareness and knowledge are important, however the vision relies more on government and institutions for changes (A1. 7), Society awareness is not a central strategy to improve sustainability (A2. 8)

Consumers should be informed by labels and certification schemes (B3)

There is a lack of interest by government for changes in the agri-food system because of corruption or economic benefits with the current system by small powerful groups and a lack of pressures from society on government for change (A1. 7)

Development of co-responsibility towards sustainability between farmers and consumers is an interesting and welcomed strategy, but it is not central ideas in this vision (A1. 12, A2. 10)

Future vision II – Radical transformation

Detailed perspective

Equity & social welfare

There would be a gradual and strong improvement in society equity by redistribution of land and wealth (table 10). A There would be a restriction to the concentration of land, power and capital (A1. 1.). Agri-food system should bring balanced benefits to the whole society and not for a minority (A1. 1.). It requires radical change, like limiting size of large farms (A2. 1.) and high improvements on quality of education (A2. 1.). Public support would be gradually transferred towards sustainable agriculture by small-scale family farmers and medium farmers (A1. 11). There would be a massive investment for transferring social and more sustainable technologies through technical assistance, based exclusively on sustainable agriculture (A2. 4.). National policy needs to balance power among stakeholders. Currently, it mostly attends a very strong sector in the National Congress (BBB) (B3). Use market to force government to promote social benefits on policies is an alternative strategy, however is not essential (B3). A crucial element for both visions that requires changes in policies and society behaviour is education for sustainability (formal and informal). Several stakeholders mentioned education for citizenship the central point for a transition towards sustainability. Some stakeholders believe that is necessary to change the current agricultural model.

Economic stability & investment

Solidarity economy is one of the main strategies to bring sustainability to the agri-food system in this vision (A2. 8) and change the paradigm of economic development (table 10). Economic incentives and public credit would be applied exclusively to small-scale family farmers and medium farmers, which adopt sustainable agriculture (A2. 9). Investment in big infrastructure is important, but not priority. Focus would be on regional and local infrastructure for community (A1. 2., A2. 2.)

Culture & tradition preservation

Traditional culture preservation is high priority and one of the pillars of the sustainability concept (A1. 4). In this vision socio-biodiversity would be valued and preserved, heirloom seeds for example (table 10, C). Traditional people and knowledge would be taking into account in policy frameworks to promote and achieve sustainability. The technical assistance would be permanent and developed in co-operation with small-scale family farmers and traditional communities respecting these values.

Ecosystem services maintenance & biodiversity conservation

Ecosystem services maintenance and biodiversity conservation are key elements for the sustainability improvement of the Brazilian agri-food system. One specific point of this vision is the care for the soil management, valuing the quality of organic matter, for example (table 10). These improvements would be promoted by the adoption of sustainable agriculture also considering landscape context (table 10, C), the multi-use of agriculture (table 10, C) and conservation of natural resources (forest, water, soils, climate, etc) (table 10, C).

Use of natural resources and pollution

In this vision, the use of sustainable agriculture is the central strategy to improve management of natural resources and for the sustainability of the Brazilian agri-food system. Some practices mentioned by stakeholders, that suit both visions, are (C, table 3):

- wide adoption of low carbon emission agriculture
- optimization of land use by avoiding new deforestation
- supply green belts (referring to the production areas surrounding cities)
- expand the adoption of integrated management of pests and diseases (reduction in the use of pesticides)
- a preponderance of integrated production systems
- efficient system reducing waste

- highly efficiency in the use of natural resources
- sustainable technology
- water and soil conservation

Some specific elements from sustainable agriculture for the Radical transformation vision are:

Public credit and technical assistance would be part of the same package and would be gradually transferred to small-scale family farmers and medium farmers with the condition of applying sustainable agriculture (B3, A2. 5). Credit needs radical change and improvement. Large farmers would have access to private credit and technical assistance. Technical assistance is the obstacle. Technologies are not adequately transferred to farmers. It would develop farmers and consumers co-responsibility (B3). There would be a radical improvement on the use of soil, water and animal ethics (A1. 6). There would be an elimination of agrochemicals (table 10) and restriction on size of farms to avoid big monocultures (A2. 6). There is a consensus that the lack of control, inspection and regularization is a big problem to the system. These are important mechanisms of change, based on sustainable agriculture parameters (agroecology, agroforestry, organic), structured in a participatory way and with a strong societal protagonism (A1. 9, B3.).

It is important to improve regulation and implementation of policies, but the vision is mainly a bottom up approach. It has society change as the most important mechanism of change (B3). Through the use of sustainable agriculture there would be a low dependence on external subsidy (A1. 3) aiming to achieve a positive energy balance (table 10). Sustainable agriculture is central to improve management of resources (A2. 3) and avoid the current strong degradation of ecosystem services (A1. 5.). Therefore there would be a strong incentive for the integration and diversification of food production system with especial attention to agroforestry, local food and urban agriculture (table 3).

Governance: policy

Some stakeholders' ideas about changes in national policy that suit both visions are needs to:

- enhance the sustainability issue in irrigation law. Improve the legal framework to conserve water resources
- environmental (RL** and APP***) and land regularization
- adapt the legal framework to family farming and extractivism
- create laws that encourage sustainable practices and do not bring difficulties or coercion for food production and consumption, or environmental conservation;

Some changes in national policy specifically for the Radical transformation vision are:

A transition towards sustainable agriculture by small-scale family farmers and medium farmers is central to the vision. Local production and consumption would be priority (A1. 8.). Conversion and adaptation of policies for a sustainability and conservation of ecosystem services is very important together with the use of financial mechanisms to ensure variety of agricultural products (A2. 7). It is essential to create more space, policies and investment to promote local and sustainable agriculture, gradually excluding public investment for conventional and large agriculture (A2. 9.). Control of agriculture by the national State and end of foreign intervention (table 10). Public support for agribusiness for exportation would be gradually reduced (table 10), focusing on small-scale family farmers and medium farmers. Use of agrochemical and GMOs would be gradually eliminated, remaining only sustainable agriculture (table 10, B3). Develop an industrial mechanism to add value to products from small and medium farmers (B3). Develop technologies built in partnership with small-scale family farmers and traditional communities (B3). Agricultural policies would strongly consider territory planning and participatory process (B3) and encourage people to return and remain in the countryside (table 10). Strength PLANAPO to promote agroecology and organic agriculture is a central strategy for the vision (B3).

Governance: behaviour

Some stakeholders' ideas about necessary changes in Brazilian behaviour that can suit both visions are:

- reduce the consumption of beef
- promote reflection on society on sustainable consumption
- education for consumption (e.g. packaging, harvests, local production, reduce meat consumption)
- change Brazilian style of food consumption
- consumers aware of their choices

Some ideas about changes in the Brazilian behaviour, specific for the Radical transformation vision are:

Population awareness and knowledge is high priority, the diffusion of awareness comes from civil society and government (A1. 7.). Society awareness is an essential strategy to improve sustainability. There would be a 'cultural revolution', creative freedom, radical change, solidarity economy, reduction of power from multinationals and market. Market tools would be managed to stop privileging major industries (A2. 8.). Consumers would be informed by labels, participatory certification, CSA, street markets (table 10, B3). Lack of interest from government for change, corruption, economic benefits from small powerful groups and lack of pressure for change from population are serious problems (A1. 10.). Direct connection between farmers and consumers is central and essential (table 10, A1. 12.), developing co-responsibility towards sustainability (A2. 10.). There would be a consumption of products from local biodiversity (table 10). Society would be encouraged develop the culture of care, food culture "Cult Food", non-anthropocentric nature (table 10).

Appendix 8. Transition pathways for a sustainable Brazilian agri-food system

I present the compilation and categorization of the measures into strategies in appendix 11 (figure) and 12 (table) for the In-depth reform vision, and in appendix 13 (figure) and 14 (table) for the Radical transformation vision. Both figures (appendices) have the same set of measures and strategies; however, a different classification for each vision. Following the definition of each vision (see table 10 and appendix 7), I classify the measures representing core ideas and priorities (dark green), complementary and not priority (intermediate green), not significant or not aligned with the vision (lighter green), main mechanisms of change (purple) and conflicting with the vision (red). Appendices (tables) 12 and 14 have only the core ideas and priorities (dark green) and conflicting ideas (red) for each vision. The measures are divided into twelve strategies: Better management practices, Promote sustainable technology, Policies for sustainability, Effective government control, Financing and credit, Social governance, Technical assistance, Local, sustainable and decentralized agriculture, Communication and campaign, Education, research and university extension, Co-responsibility and sustainable consumption and Society mobilization. The horizontal dashed blue line in the centre of the Appendices 11 and 13 divides the measures that tend to have a top down (top of the figure) and bottom up approach (bottom of the figure). Hence, the measures closest to the top tend to be more dependent on or coming from government actions and the measures closest to the bottom tend to be more dependent on or coming from society and individual actions. In the centre of the figures, measures can be dependent on or come from both government and civil society (acting together or separately) and/or from market, public or private institutions and individuals. The vertical blue lines divide the measures into technological, structural and cultural changes. I collected the measures classified with yellow letters and numbers (S1, S2, G1, G2 etc.) from the feedbacks of the future visions workshop and note-taking from interviews. These measures were discussed with stakeholders during the transition pathways workshop. The other measures come from a later and more detailed analysis of the transcriptions of the interviews.

Appendix 9. Overview of the material used in the transition pathways workshop

Appendix 10. Support material for the discussion of measures of sustainability

In-depth Reform vision

Top down

Public policies for sustainability

Effective government control

S19. Use sustainability criteria for development policies

Public policies for sustainability - have transformative leadership in key position, such as president of the republic, ministers

Public policies for sustainability - executive and legislative government commit to convert public policies to promote sustainability

Include other indicators for development goals and for formulation of public policies

effective government control - increase monitoring of the use of agrochemicals and natural resource

effective government control - to promote land regularization

G8. Regulation, taxation and monitoring of agrochemicals and oil-intensive chains 1

S8. International agreements as the North and basis for sustainability (with critical caveats)

Public policies for sustainability - national sustainability agenda must be linked to the international agenda

Public policies for sustainability - government set up a task force to make a diagnosis and policy proposals for the management of the production system

Public policies for sustainability - work in a governmental proposal based on climate issues

G16. land tenure (TerraClass, etc.)

Improvement and effectiveness of land and environmental regulatory mechanisms (CF and CAR)

G5. Environmental regulation (CAR, RL, APP, PPA, Environmental Licensing) 2

effective government control - implement environmental legislation, improving the environmental quality of properties

G9. Restrictions on the concentration of power in the food production and consumption chain

G4. Integrating infrastructure with sustainability criteria

Public policies for sustainability - structure the Brazilian logistics with railways and waterways

Public policies for sustainability - to manage the territory using the policy of cities, the laws of cities, urban planning mechanisms

Effective government control - government should be stricter in monitoring and combating corruption and promoting justice

G15. Media reform, avoiding concentration of power and ensuring free and independent, culture and info

Technical assistance

G13. Technical assistance with sustainability criteria and inclusion (social technology) 2

Technology / technical assistance - government should ensure access to technologies, centred in the massive investment in technical assistance

Technology / technical assistance – EMATER should be strengthened, expanded and redirected to focus on sustainability

Technology / technical assistance - Establish the ANATER (National Agency for Technical Assistance and Rural Extension) ensuring dissemination and implementation of technical assistance at federal, state and municipal levels

Technology / technical assistance - make room for private and non-profit non-governmental technical assistance, both oriented with sustainability objectives

Improve the transfer of technology - to strengthen the mechanism of transferring new technologies to small and medium farmers through technical assistance by Emater

Financing and credit

G14. ABC plan and sustainability criteria as the basis for the SAFRA plan

Public funding / credit - PPA should guarantee resources for all farmers fairly

public / credit financing - ABC plan should serve as criteria and parameters for the SAFRA plan

Public funding / credit - generate incentives and compensation for recovery and conservation of forests and reducing emissions

G17. Credit with sustainability criteria and inclusive

public / credit financing - financing should be linked to sustainability standards, the long-term planning focused on the territory: access to land and technical assistance

financing instruments and subsidies - technical information to support the offer of rural credit by banks

Public funding / credit - production incentives should account social and environmental externalities of the entire production chain

S18. Supporting funders with the development of decision-making mechanisms based on sustainability criteria

financing instruments and subsidies - to quantify environmental costs of agricultural production

Public finance/credit-simplify and facilitate access to credit and insurance to farmers, especially small undercapitalized farmers

Facilitate access to a systemic and differentiated credit for family farming

G20. Reduce bureaucracy, unification of taxes and tariffs

Public policies for sustainability - restructure the production policy

public / credit financing - new credit should be more extensive to unsustainable production (conventional)

Strengthening public policies that benefit sustainability - Disincentive to productive chains with high dependency on oil

Public funding / credit - create incentives to develop the chain of certain products and local industry

G10. PAA expansion - Food Acquisition Program

Local, sustainable and decentralized agriculture

local and sustainable agriculture - improve purchasing and marketing systems supporting farmers and facilitating consumers access to products from sustainable agriculture in the municipal, state and federal levels through initiatives such as the PPA (Food Acquisition Program), PNAE (National School Feeding Program), the open markets, ensuring a good price to farmers and at the same time an affordable price to consumers

PNAE Expansion - National School Feeding Programme

regionalized agricultural policy - decentralized trade structures

regionalized agricultural policy - regional business models for family farming

local and sustainable agriculture - Create more space, initiatives, policies and investments for sustainable and local agriculture, agro-ecological systems, small and intermediate farmers

Promote sustainable technology

G2. Research and development for sustainable production, including machinery and equipment, and exchanges between researchers, rural extensionists and farmers

Promoting sustainable technologies - redirect and increase investment and stimulate research of sustainable technologies

Improve the transfer of technology - combining technology and environmental and territorial regulation

Better management practices - BMP

BMP - subsidies for sustainable equipment

BMP - agrochemicals control

BMP - adoption of more efficient machines that use less energy

S16. Monoculture, intensive agriculture and GMO certified with sustainability criteria

Facilitate certification

G16. Expansion of government certification with sustainability criteria

S14. Expansion of private certification with sustainability criteria

S13. Expansion of participatory certification with sustainability criteria

S17. Intensification of livestock and agrosilvopastoral systems with sustainability criteria (more rigid)

BMP - increasing the efficiency of renewable energy sources

Working conditions and technology transfer - training along the chain to enhance technology transfer

Engaging sustainability and technology

Breaking the technological paradigm/ cultural -technology promoting sustainable intensification

BMP - intensification of livestock

Changes in livestock practices - promote silvopastoral systems for recovering degraded areas

Increase agricultural productivity, emphasis on agroecology

BMP - use of agroforestry in APP and Legal Reserve

BMP - integrated system, taking care of the soil, water and being connected to the local system

Improve the transfer of technology - credit to family farmers to access technology and health in agricultural work

Investment in research and development - use of more efficient technologies and with transformative role (e.g. technologies for complex systems, agroforestry.)

Promoting sustainable technologies - use the current structure to develop new technologies with long-term sustainability vision, associated with agroecological systems

Promoting sustainable technologies - strengthen sustainable social technologies

Improve the transfer of technology - increase information about the availability of sustainable technologies that are alternatives to the conventional system

Breaking the technological paradigm / cultural - integration technology and ecology. Human seen as part of nature

G5. Create and strengthen policies for medium farmers

Strengthening public policies that benefit sustainability - ensuring access to adequate food

G6. policy system reform (e.g. campaign not privately funded)

Public policies for sustainability - policy reform, more involvement and engagement of politicians with whom elect them and vice versa

G3a. Payment for ecosystem services

Public policies for sustainability - leverage the payment for environmental services and carbon credit

Strengthening public policies that benefit sustainability - payment for environmental services

economic incentives for sustainability - mechanisms of donation for recovery of degraded areas and for sustainable production, carbon credit, green bond

G23. Reduce bureaucracy, unification of taxes and tariffs

Public policies for sustainability - restructure the production policy

Public policies for sustainability - tax reduction for sustainable and organic production

G24. Tax reduction for sustainable production 1

Strengthening public policies that benefit sustainability - encouraging sustainable production

Strengthening public policies that benefit sustainability - establish legal framework on marketing and production of products from sociobiodiversity

Public policies for sustainability - ensuring variety of products

G22. Valuation of sustainable food (change by economic incentive)

Breaking the technological-cultural paradigm - to value and conserve biodiversity and natural resources in general

Strengthening public policies that benefit sustainability - Valuation of natural resources as embedded costs in production

Education, research and university extension

G21. Rural education (primary education, EPA, its ...) 2

Education for citizenship to strengthen education in rural areas, including new schools

S6. Reshape the curricula of agricultural courses based on sustainability and citizenship

S7. Reshape the basic education curriculum (primary and secondary) with sustainable bases and for citizenship

Education for citizenship - reformulate all school curricula from childhood until universities focusing on citizenship training and including agricultural education

Education for citizenship - Revise school curricula, emphasizing environmental education

Education, research and extension - Structural changes in teaching (integration of human being and environment, promote art and culture)

Education for citizenship - systemic, participatory and adaptive education

Education for citizenship - education to promote a sense of responsibility

Education, research and extension - promote university extension and partnerships between researchers, rural extensionists and farmers

Promoting sustainable technologies - Provide exchange, interaction and cooperation, exchanges between universities, businesses and farmers

Education for citizenship – university with focus on promoting sustainable agriculture

Communication and Campaign

Agriculture local e sustentável - comunicar e fortalecer bons exemplos de sustentabilidade

S10. Promoção da mídia e cultura independente livre

Comunicação e campanha - promover conceitos e experiências sustentáveis bem sucedidas em campanhas utilizando redes e mídias alternativas para informar a sociedade

Social governance

Greater social governance - The National Congress has an essential role to create these mechanisms

S1. Democratic and decentralized territorial planning (ZEE, basin committees, Climata adaptation, law of cities, master plans) and with sustainable base 1

Reform of the national agrarian structure - inclusive and sustainable territorial planning (ecological-economic zoning, basin committees, hydrologic conservation units)

Greater social governance - establishing participatory, democratic and decentralized systems of nature management

Mobilization of civil society - to create horizontal and less bureaucratic system to enlarge the spaces of decision and citizenship

G1a. Land reform, distributing and restricting maximum size of property

Redistribution of wealth

Public policies for sustainability - create policies to promote equity, such as distribution of land by land reform and income distribution

G19. Policies for the return of the population to rural areas

Strengthen policies for traditional communities 1

Family agriculture as a strategic focus for the country / domestic market 2

Public policies for sustainability - family farms must be strengthened and prioritized as a strategic focus for the country

G9. Strengthening and engagement to CONDRAF - National Council for Rural Development and Family Agriculture (joint)

Public policies for sustainability - establishment of public policies to strengthen civil society and organized and autonomous social movements

G12. Strengthening and engagement to PLANAPO - National Plan for Agroecology and Organic Production

Public policies for sustainability - definition of PPA with greater involvement of civil society

Co-responsibility / sustainable consumption

G18. SEBRAE campaign

Co-responsibility / sustainable consumption - strengthen campaigns as SEBRAE: "buy from the small"

Regulation of advertising and product information

G7. Detailed labelling of the production chain (GMOs, agrochemicals, organic, FSC etc.)

Education for citizenship - information on products through labelling

Sustainable consumption - reduction in meat demand

Co-responsibility / sustainable consumption - Consumer distinguishing, valuing and evoking sustainable practices along supply chain

S15. Strengthening and Expansion of CSAs - Community Supported Agriculture 1

Direct support of the urban population to farmers - CSA

Co-responsibility / sustainable consumption - direct purchase from farmers of local and seasoned products

S3. Society options for Solidarity Economy and Sustainable Consumption 1

Sustainable consumption - increased consumption of organic, agroecological, social socio-biodiverse and minimally processed food

Sustainable consumption - radical rejection of harmful products, ultra-processed foods

Dissemination of urban agriculture

Openness to new solutions - release of prejudices and other preconceived ideas to enable new solutions

S11. Education based on planetary citizenship / Environmental Education

Society mobilization

Social mobilization - stakeholders' network to sustainability, which already exists: CSA, which operates independently of the control of market or policies farmers' street market urban agriculture family farming land reform protection of natural ecosystems agroforestry courses organic certification gardening individual changes, convincing two or three people also to change themselves mobilization of all organized society, academia, legislative, executive and judicial

S2. Articulation and action network for sustainability / Connecting production and consumption 2

Mobilization of civil society - to create mechanisms for more effective social control, the form of representation, decision networks, councils, solidarity economy, fair trade, consumers - family farmers, cooperatives, associativism, CSA movement, urban agriculture movement

S12. Strengthening and engagement with urban agriculture

Education for citizenship - strong demand from civil society

Mobilization of civil society - non-governmental stakeholders initiatives to press the government to create public policies aligned with sustainability goals (coalition NGOs and business, e.g.)

Mobilization of civil society – initiatives from non-governmental stakeholders to press the government to create public policies aligned with sustainability goals (coalition NGOs and business, e.g.)

Reform of the national agrarian structure - Society should strengthen multidimensional-institutional instruments of decision in a democratic and independent basis, and monitor legislative and executive

Radical break for transformation of the Brazilian agri-food system - overthrow of capitalism

Radical break for transformation of the Brazilian agri-food system - use of precaution

Awareness - awareness of the benefits of sustainability and account for the production system externalities

Awareness - the general interest of the population in sustainability issues, care of the place, love and respect for the land, water and whole food production process

Awareness - Farmer understand the environment as an asset and not an obstacle to production

Awareness - beware of personal health (organic, water, climate), leaving the remedy logic to go for health logic

Society mobilization - society create spaces of collaboration with more sociability and more dialogue

Society mobilization - citizens taking action towards sustainability, engaging and giving support to NGOs

Society mobilization - citizens voting better, practicing democracy

S9. political engagement of the society for the transition (election / pressure) 1

Bottom up

Appendix 12. Main measures into strategies for the In-depth reform vision (table)

Better management practices - BMP	Public policies for sustainability	Effective government control	Social governance	Education, research and university extension	Society mobilization
BMP - subsidies for sustainable equipment	Public policies for sustainability - have transformative leadership in key position, such as president of the republic, ministers	effective government control - increase monitoring of the use of agrochemicals and natural resources	Greater social governance - The National Congress has an essential role to create these mechanisms	Education for citizenship - to strengthen education in rural areas, including new schools	Radical break for transformation of the Brazilian agri-food system - overthrow of capitalism
BMP - agrochemicals control	Public policies for sustainability - executive and legislative government commit to convert public policies to promote sustainability	effective government control - to promote land regularization		Education for citizenship - reformulate all school curricula from childhood until universities focusing on citizenship training and including agricultural education	Radical break for transformation of the Brazilian agri-food system - use of precaution
BMP - adoption of more efficient machines that use less energy	Public policies for sustainability - national sustainability agenda must be linked to the international agenda	Improvement and effectiveness of land and environmental regulatory mechanisms (CF and CAR)	**Technical assistance**	Education for citizenship - Revise school curricula, emphasizing environmental education	
Public policies for sustainability - facilitate certification	Public policies for sustainability - structure the Brazilian logistics with railways and waterways	effective government control - implement environmental legislation, improving the environmental quality of properties	Technology / technical assistance - government should ensure access to technologies, centred in the massive investment in technical assistance	Education, research and extension - promote university extension and partnerships between researchers, rural extensionists and farmers	
Breaking the technological paradigm / cultural -technology promoting sustainable intensification	Public policies for sustainability - to manage the territory using the policy of cities, the laws of the cities, urban planning mechanisms	Effective government control - government should be stricter in monitoring and combating corruption and promoting justice	Technology / technical assistance - EMATER should be strengthened, expanded and redirected to focus on sustainability	Promoting sustainable technologies -Provide exchange, interaction and cooperation, exchanges between universities, businesses and farmers	
BMP - intensification of livestock	Strengthening public policies that benefit sustainability - ensuring access to adequate food	**G1b.** land tenure (TerraClass, etc.)	Technology / technical assistance - Establish the ANATER (National Agency for Technical Assistance and Rural Extension) ensuring dissemination and implementation of technical assistance at federal, state and municipal levels	**G23.** Rural education (primary education, EFA, Ifs ...) 2	

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Changes in livestock practices - promote silvopastoral systems for recovering degraded areas	Public policies for sustainability - policy reform, more involvement and engagement of politicians with whom elected them and vice versa	G9. Restrictions on the concentration of power in the food production and consumption chain	G13. Technical assistance with sustainability criteria and inclusion (social technology) 2	S7. Recast of the basic education curriculum (primary and secondary) with sustainable basis and for citizenship 2
S16. Monoculture, intensive agriculture and GMO certified with sustainability criteria	Public policies for sustainability - leverage the payment for environmental services and carbon credit	G8. Regulation, taxation and monitoring of agrochemicals and oil-intensive chains 1		S11. Education based on planetary citizenship / Environmental Education
G16. Expansion of government certification with sustainability criteria	Strengthening public policies that benefit sustainability - payment for environmental services	G5. Environmental regulation (CAR, RL, APP, PRA, Environmental Licensing) 2	Local, sustainable and decentralized agriculture	S6. Recast of the curricula of agricultural courses based on sustainability and citizenship
S14. Expansion of private certification with sustainability criteria	economic incentives for sustainability - mechanisms of donation for recovery of degraded areas and for sustainable production, carbon credit, green bond			
S17. Intensification of livestock and agrosilvopastoral systems with sustainability criteria (more rigid)	Public policies for sustainability - restructure the production policy	Financing and credit	Communication and Campaign	Co-responsibility / sustainable consumption
	Strengthening public policies that benefit sustainability - encouraging sustainable production	Public funding / credit - PPA should guarantee resources for all farmers fairly		Sustainable consumption - radical rejection of harmful products, ultra-processed foods
Promote sustainable technology	S19. Use sustainability criteria for development policies	public / credit financing - ABC plan should serve as criteria and parameters for the SAFRA plan		
Promoting sustainable technologies - redirect and increase investment and stimulate research of sustainable technologies	S8. International agreements as the North and basis for sustainability (with critical caveats)	Public funding / credit - generate incentives and compensation for recovery and conservation of forests and reducing emissions		
Improve the transfer of technology - combining technology and environmental and territorial regulation	G4. integrating infrastructure with sustainability criteria	public / credit financing - financing should be linked to sustainability standards, the long-term planning focused on the		

		territory, access to land and technical assistance			
BMP - increasing the efficiency of renewable energy sources	**G6.** policy system reform (e.g. campaign not privately funded)	financing instruments and subsidies - technical information to support the offer of rural credit by banks			
Working conditions and technology transfer - training along the chain to enhance technology transfer	**G3a.** Payment for ecosystem services	public / credit financing - rural credit should be more expensive to unsustainable production (conventional)			
Engaging sustainability and technology	**G1a.** Land reform, distributing and restricting maximum size of property	Strengthening public policies that benefit sustainability - Disincentive to productive chains with high dependency on oil			
G2. Research and development for sustainable production, including machinery and equipment, and exchanges between researchers, rural extensionists and farmers		**G14.** ABC plan and sustainability criteria as the basis for the SAFRA plan			
		G12. Credit with sustainability criteria and inclusive			
		S18. Supporting funders with the development of decision-making mechanisms based on sustainability criteria			

Appendix 13. Measures and strategies of the Radical transformation (figure)

Radical transformation vision

Top down

Public policies for sustainability

Effective government control

Technical assistance

Promote sustainable technology

Financing and credit

Local, sustainable and decentralized agriculture

Better management practices - BMP

Education, research and university extension

Co-responsibility / sustainable consumption

Communication and Campaign

Social governance

Society mobilization

Bottom up

Technological changes

Structural changes

Cultural changes

Appendix 14. Main measures into strategies for the Radical transformation vision (table)

Better management practices - BMP	Public policies for sustainability	Effective government control	Social governance	Education, research and university extension	Society mobilization
Increase agricultural productivity, emphasis on agroecology	Strengthening public policies that benefit sustainability - ensuring access to adequate food	**G9.** Restrictions on the concentration of power in the food production and consumption chain	Reform of the national agrarian structure - inclusive and sustainable territorial planning (ecological-economic zoning, basin committees, hydrologic conservation units)	Education for citizenship - to strengthen education in rural areas, including new schools	Social mobilization - stakeholders' network to sustainability, which already exists: CSA, which operates independently of the control of market or policies farmers' street market urban agriculture family farming land reform protection of natural ecosystems agroforestry courses organic certification gardening individual changes, convincing two or three people also to change themselves mobilization of all organized society, academia, legislative, executive and judicial
BMP - use of agroforestry in APP and Legal Reserve	Public policies for sustainability - tax reduction for sustainable and organic production	**G17.** Media reform, avoiding concentration of power and ensuring free and independent culture and info	Greater social governance - establishing participatory, democratic and decentralized systems of nature management	Education for citizenship - reformulate all school curricula from childhood until universities focusing on citizenship training and including agricultural education	Mobilization of civil society - to create mechanisms for more effective social control, the form of representation, decision networks, councils, solidarity economy, fair trade, consumers - family farmers, cooperatives, associativism, CSA movement, urban agriculture movement
BMP - integrated system, taking care of the soil, water and being connected to the local system	Strengthening public policies that benefit sustainability - encouraging sustainable production		Mobilization of civil society - to create horizontal and less bureaucratic system to enlarge	Education for citizenship - Revise school curricula, emphasizing environmental education	Education for citizenship - strong demand from civil society

			the spaces of decision and citizenship		
S16. Monoculture, intensive agriculture and GMO certified with sustainability criteria	Strengthening public policies that benefit sustainability - establish legal framework on marketing and production of products from sociobiodiversity	**Financing and credit**	**S1.** Democratic and decentralized territorial planning (ZEE, basin committees, Climate adaptation, law of cities, master plans) and with sustainable base 1	Education, research and extension - Structural changes in teaching (integration of human being and environment, promote art and culture)	Mobilization of civil society - non-governmental stakeholders initiatives to press the government to create public policies aligned with sustainability goals (coalition NGOs and business, e.g.)
S13. Expansion of participatory certification with sustainability criteria	Public policies for sustainability - ensuring variety of products	Public funding / credit - PPA should guarantee resources for all farmers fairly		Education for citizenship - systemic, participatory and adaptive education	Mobilization of civil society – initiatives from non-governmental stakeholders to press the government to create public policies aligned with sustainability goals (coalition NGOs and business, e.g.)
	Redistribution of wealth	public / credit financing - financing should be linked to sustainability standards, the long-term planning focused on the territory, access to land and technical assistance	**Technical assistance**	Education for citizenship - education to promote a sense of responsibility	Reform of the national agrarian structure - Society should strengthen multidimensional-institutional instruments of decision in a democratic and independent basis, and monitor legislative and executive
Promote sustainable technology	Public policies for sustainability - create policies to promote equity, such as distribution of land by land reform and income distribution	financing instruments and subsidies - technical information to support the offer of rural credit by banks	Technology / technical assistance - government should ensure access to technologies, centred in the massive investment in technical assistance	Education, research and extension - promote university extension and partnerships between researchers, rural extensionists and farmers	Radical break for transformation of the Brazilian agri-food system - overthrow of capitalism
Engaging sustainability and technology	Public policies for sustainability - family farms must be strengthened and prioritized as a strategic focus for the country	Public finance/credit-simplify and facilitate access to credit and insurance to farmers, especially small undercapitalized farmers	Technology / technical assistance - EMATER should be strengthened, expanded and redirected to focus on sustainability	Promoting sustainable technologies -Provide exchange, interaction and cooperation, exchanges between universities, businesses and farmers	Radical break for transformation of the Brazilian agri-food system - use of precaution
Improve the transfer of technology - credit to family farmers to access technology and health in agricultural work	Public policies for sustainability - establishment of public policies to strengthen civil society and	Facilitate access to a systemic and differentiated credit for family farming	Technology / technical assistance - Establish the ANATER (National Agency for Technical Assistance and Rural Extension)	Education for citizenship – university with focus on promoting sustainable agriculture	Awareness - awareness of the benefits of sustainability and account for the production system externalities

	organized and autonomous social movements		ensuring dissemination and implementation of technical assistance at federal, state and municipal levels		
Investment in research and development - use of more efficient technologies and with transformative role (e.g. technologies for complex systems, agroforestry.)	Public policies for sustainability - definition of PPA with greater involvement of civil society	public / credit financing - rural credit should be more expensive to unsustainable production (conventional)	Improve the transfer of technology - to strengthen the mechanism of transferring new technologies to small and medium farmers through technical assistance by Emater	**G23.** Rural education (primary education, EFA, Ifs ...) 2	Awareness - the general interest of the population in sustainability issues, care of the place, love and respect for the land, water and whole food production process
Promoting sustainable technologies - use the current structure to develop new technologies with long-term sustainability vision, associated with agroecological systems	**S19.** Use sustainability criteria for development policies	Strengthening public policies that benefit sustainability - Disincentive to productive chains with high dependency on oil	**G13.** Technical assistance with sustainability criteria and inclusion (social technology) 2	**S7.** Recast of the basic education curriculum (primary and secondary) with sustainable basis and for **citizenship** 2	Awareness - Farmer understand the environment as an asset and not an obstacle to production
Promoting sustainable technologies - strengthen sustainable social technologies	**G19.** Create and strengthen policies for medium farmers	Public funding / credit - create incentives to develop the chain of certain products and local industry		**S11.** Education based on planetary citizenship / Environmental Education	Society mobilization - society create spaces of collaboration with more sociability and more dialogue
Improve the transfer of technology – increase information about the availability of sustainable technologies that are alternatives to the conventional system	**G3b.** Tax reduction for sustainable production 1	**G12.** Credit with sustainability criteria and inclusive	Local, sustainable and decentralized agriculture	**S6.** Recast of the curricula of agricultural courses based on sustainability and citizenship	Society mobilization - citizens taking action towards sustainability, engaging and giving support to NGOs
Breaking the technological paradigm / cultural - integration technology and ecology. Human seen as part of nature	**G1a.** Land reform, distributing and restricting maximum size of property	**S18.** Supporting funders with the development of decision-making mechanisms based on sustainability criteria	local and sustainable agriculture - Improve purchasing and marketing systems supporting farmers and facilitating consumers access to products from sustainable agriculture in the municipal, state and federal levels through initiatives such as the PPA (Food Acquisition Program), PNAE (National School Feeding Program), the open markets, ensuring a good price to farmers and at the same		Society mobilization - citizens voting better, practicing democracy

			time an affordable price to consumers		
G2. Research and development for sustainable production, including machinery and equipment, and exchanges between researchers, rural extensionists and farmers	**G18.** Policies for the return of the population to rural areas		regionalized agricultural policy - decentralized trade structures	**Co-responsibility / sustainable consumption**	**S4.** Articulation and action network for sustainability / Connecting production and consumption 2
	G21. Strengthen policies for traditional communities 1		regionalized agricultural policy - regional business models for family farming	Co-responsibility / sustainable consumption - Consumer distinguishing, valuing and evoking sustainable practices along supply chain	**S12.** Strengthening and engagement with urban agriculture
	S5. Family agriculture as a strategic focus for the country / domestic market 2		local and sustainable agriculture - Create more space, initiatives, policies and investments for sustainable and local agriculture, agro-ecological systems, small and intermediate farmers	Direct support of the urban population to farmers - CSA	**S2.** political engagement of the society for the transition (election / pressure) 1
	S9. Strengthening and engagement to CONDRAF - National Council for Rural Development and Family Agriculture (joint)		**G10.** PAA expansion - Food Acquisition Program	Co-responsibility / sustainable consumption - direct purchase from farmers of local and seasoned products	
	S10. Strengthening and engagement to PLANAPO - National Plan for Agroecology and Organic Production		**G11.** PNAE Expansion - National School Feeding Programme	Sustainable consumption - increased consumption of organic, agroecological, social, socio-biodiverse and minimally processed food	
				Sustainable consumption - radical rejection of harmful products, ultra-processed foods	
			Communication and Campaign	Dissemination of urban agriculture	
			Agricultura local e sustentável - comunicar e fortalecer bons exemplos de sustentabilidade	Openness to new solutions - release of prejudices and other preconceived ideas to enable new solutions	

			Comunicação e campanha - promover conceitos e experiências sustentáveis bem sucedidas em campanhas utilizando redes e mídias alternativas para informar a sociedade	**S15.** Strengthening and Expansion of CSAs - Community Supported Agriculture 1	
			S20. Promoção da mídia e cultura independente livre	**S3.** Society options for Solidarity Economy and Sustainable Consumption 1	

Appendix 15. Main strategies and measures for alternative pathways for the sustainability of the Brazilian agri-food system

Better management practices - BMP	Public policies for sustainability	Effective government control	Social governance	Education, research and university extension	Society mobilization
BMP - agrochemicals control	Public policies for sustainability - national sustainability agenda must be linked to the international agenda	effective government control - to promote land regularization	S1. Democratic and decentralized territorial planning (ZEE, basin committees, Climate adaptation, law of cities, master plans) and with sustainable basis	Education for citizenship - to strengthen education in rural areas, including new schools	Mobilization of civil society - to create mechanisms for more effective social control, the form of representation, decision networks, councils, solidarity economy, fair trade, consumers - family farmers, cooperatives, associativism, CSA movement, urban agriculture movement
BMP - intensification of livestock	S8. International agreements as the North and basis for sustainability (with critical caveats)	Improvement and effectiveness of land and environmental regulatory mechanisms (CF and CAR)		Education for citizenship - reformulate all school curricula from childhood until universities focusing on citizenship training and including agricultural education	Mobilization of civil society - non-governmental stakeholders initiatives to press the government to create public policies aligned with sustainability goals (coalition NGOs and business, e.g.)
S14. Expansion of private certification with sustainability criteria (participatory)	G4. integrating infrastructure with sustainability criteria (big infrastructure, e.g. railways, and medium infrastructure, e.g. community silos)	G1b. land tenure (TerraClass, etc.)	**Technical assistance**	Education for citizenship - systemic, participatory and adaptive education	Society mobilization - citizens taking action towards sustainability, engaging and giving support to NGOs
S17. Intensification of livestock and agrosilvopastoral systems with sustainability criteria (more rigid)	G6. policy system reform (e.g. campaign not privately funded)	G9. Restrictions on the concentration of power in the food production and consumption chain	Technology / technical assistance - government should ensure access to technologies, centred in the massive investment in technical assistance	Education for citizenship - education to promote a sense of responsibility	S2. political engagement of the society for the transition (election / pressure) 1
	G3a. Payment for ecosystem services (Fund for community and lansdcape benefits co-managed by farmers association, local structure of CONDRAF and international donnor)	G8. Regulation, taxation and monitoring of agrochemicals and oil-intensive chains 1	Technology / technical assistance - EMATER should be strengthened, expanded and redirected to focus on sustainability	Education, research and extension - promote university extension and partnerships between researchers, rural extensionists and farmers	

Promote sustainable technology	**G1a.** Land reform, distributing and restricting maximum size of property	**G5.** Environmental regulation (CAR, RL, APP, PRA, Environmental Licensing) 2	Technology / technical assistance - Establish the ANATER (National Agency for Technical Assistance and Rural Extension) ensuring dissemination and implementation of technical assistance at federal, state and municipal levels	Education for citizenship – university with focus on promoting sustainable agriculture	
G2. Research and development for sustainable production, including machinery and equipment, and exchanges between researchers, rural extensionists and farmers	Strengthening public policies that benefit sustainability - establish legal framework on marketing and production of products from sociobiodiversity		**G13.** Technical assistance with sustainability criteria and inclusion (social technology) 2		
Promoting sustainable technologies - strengthen sustainable social technologies	Redistribution of wealth	**Financing and credit**		**Co-responsibility / sustainable consumption**	
	Public policies for sustainability - create policies to promote equity, such as distribution of land by land reform and income distribution	Public funding / credit - PPA should guarantee resources for all farmers fairly **(with an increase direction to small-scale family farmers and medium farmers)**	**Local, sustainable and decentralized agriculture**	Co-responsibility / sustainable consumption - Consumer distinguishing, valuing and evoking sustainable practices along supply chain	
	Public policies for sustainability - family farms must be strengthened and prioritized as a strategic focus for the country	public / credit financing - financing should be linked to sustainability standards, the long-term planning focused on the territory, access to land and technical assistance	levels through initiatives such as the PPA (Food Acquisition Program), PNAE (National School Feeding Program), the open markets, ensuring a good price to farmers and at the same time an affordable price to consumers	**S15.** Strengthening and Expansion of CSAs - Community Supported Agriculture 1	
	G19. Create and strengthen policies for medium farmers	public / credit financing - rural credit should be more expensive to unsustainable production (conventional)	local and sustainable agriculture - Create more space, initiatives, policies and investments for sustainable and local agriculture, agro-ecological systems, small and intermediate farmers	**S3.** Society options for Solidarity Economy and Sustainable Consumption 1	
	G3b. Tax reduction for sustainable production 1	Strengthening public policies that benefit sustainability -			

		Disincentive to productive chains with high dependency on oil			
	G1a. Land reform, distributing and restricting maximum size of property		**Communication and Campaign**		
	S9. Strengthening and engagement to CONDRAF - National Council for Rural Development and Family Agriculture (joint)		Comunicação e campanha - promover conceitos e experiências sustentáveis bem sucedidas em campanhas utilizando redes e mídias alternativas para informar a sociedade		
	S10. Strengthening and engagement to PLANAPO - National Plan for Agroecology and Organic Production		**S20.** Promoção da mídia e cultura independente livre		

Appendix 16. Manifestations of power for the Brazilian agri-food system

Preliminary overview of manifestations of power at the Brazilian agri-food system
Structural
MAPA and Embrapa structure to support and develop agribusiness as a mainstream "Ability to mobilize institutions supporting biased knowledge"* "Capital concentration, few supermarket chains jointly control large shares leading to buyer-driven supply chains, retailer driven food governance through private certification and auditing systems" PPA, financing "Abundant offers of cheap" food "Distributional asymmetries in land ownership and political influence" "Externalization of social costs (loss of quality of life of traditional communities and impoverishment of population diet)" "Increasing capital concentration fostering the low per unit production costs and enhanced ability to prevent undesirable regulation" "Downward pressure on labor costs through capital concentration, liberalization, free trade, labor migration"
Instrumental
Lobbyng da Bancada ruralista BBB Llobbying in the name of consumer interests on low price, even if conflicting with food safety and quality aspects" "Lobbying for/against product standards or labels" "Lobbyng governments to privatize lands" "Lobbying activities limiting animal welfare, environmental and labor standards" "Lobbying against regulations providing better access to relevant information"
Discursive
MAPA e Embrapa vision of agri-food system development "Promoting technology as the most comfortable source of solutions" "Emphasizing a company's right to business secrets rather than public's right to information" Conventional agriculture is needed and it is impossible to feed the world only with sustainable agriculture Cultivating the historical image of the conventional agriculture as being crucial for the economy and food security "Fostering belief in private ownership and free market system as beneficial for all" "Framing the acquisition of land as investment rather than land grabbing" "Considering large scale land acquisitions as most productive use of scarce resources" Diet changes to cheap and fast food Mainstreaming arguments about the benefits of free trade and the usefulness of competition

*The examples in quotation marks are recommendation from the authors. The others are suggestions elaborated in this research.