

## Drivers for agroecological transition : An analysis of 40 years of experience in Minas Gerais, Brazil

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Monteiro, Fernanda Testa; Wilson, Alexandria Jeanne; Teixeira, Heitor Mancini; Gomes, Lucas Carvalho; Bragança, Raphael Fernandes et al

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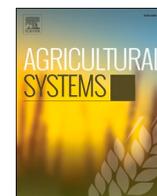
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## Drivers for agroecological transition: An analysis of 40 years of experience in Minas Gerais, Brazil

Fernanda Testa Monteiro<sup>a,\*</sup>, Alexandria Jeanne Wilson<sup>a</sup>, Heitor Mancini Teixeira<sup>b</sup>, Lucas Carvalho Gomes<sup>c</sup>, Raphael Fernandes Bragança<sup>a</sup>, Maria Izabel Vieira Botelho<sup>d</sup>, Ivonete Lopes<sup>d</sup>, Felipe N.B. Simas<sup>e</sup>, Thomas W. Kuyper<sup>f</sup>, Irene Maria Cardoso<sup>a</sup>

<sup>a</sup> Department of Soil and Plant Nutrition, Federal University of Viçosa, Brazil

<sup>b</sup> Department of Soil and Plant Nutrition, Federal University of Viçosa, Brazil and Copernicus Institute of Sustainable Development, Utrecht University, The Netherlands

<sup>c</sup> Department of Agroecology, Aarhus University, Viborg, Denmark

<sup>d</sup> Department of Rural Economics, Federal University of Viçosa, Brazil

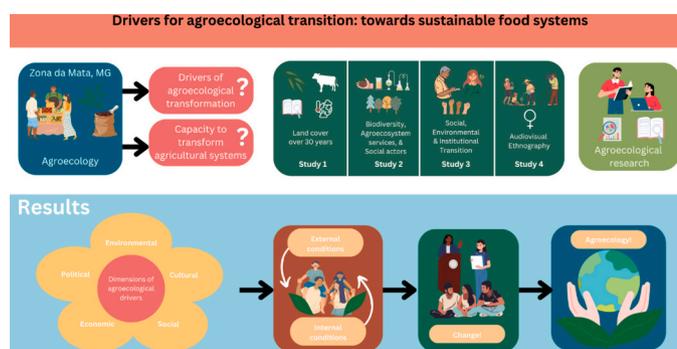
<sup>e</sup> Department of Education, Federal University of Viçosa, Brazil

<sup>f</sup> Soil Biology Group, Wageningen University & Research, P.O. Box 47, 6700 AA Wageningen, The Netherlands

### HIGHLIGHTS

- Social organization at different scales must converge into actions in favor of the agroecological transition.
- Land access, social organization of labor, cultural meanings, environmental context, and cocreation of knowledges are fundamental to agroecological transition.
- Women and youths play key roles in the agroecological transition.
- Public land use planning affects landscape transformations and the agroecological transition.
- Agroecological public policy combined with a political bottom-up movement are essential for the transition.

### GRAPHICAL ABSTRACT



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### ABSTRACT

**Context:** Efforts are being made globally to promote transformations from conventional to agroecological agricultural systems. In many places, such efforts have been made in dialogue with peasant communities, involving a range of social actors with converging actions. Understanding the drivers of such transformations can elucidate key elements capable of promoting changes in the agrifood system.

**The objective:** Was to identify and comprehend the drivers of agroecological transition and their capacity to transform the agricultural system, based on the analysis of the experience in the Zona da Mata of Minas Gerais, Brazil, where such a process has been built since the early 1980's, involving different institutions and scales of transformation.

**Methods:** We analyzed and integrated the results of four PhD theses, carried out semi-structured interviews with different social actors regarding the transition in its social, environmental, and institutional aspects, and engaged in participant observation.

\* Corresponding author.

E-mail address: [fernandamonteiro5@hotmail.com](mailto:fernandamonteiro5@hotmail.com) (F.T. Monteiro).

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*Results and conclusions:* 29 drivers were identified that promote agroecology by creating conditions and motivating peasants to switch from conventional to agroecological agriculture. These drivers act synergistically in the ecological, social, cultural, political, and economic dimensions. One crucial synergy is the combination of political support with bottom-up movements. The analysis of the drivers contributes to broadening the agroecological transition process.

*Significance:* The research is innovative by demonstrating that the analysis of drivers for agroecological transitions must be based on concrete experiences in the territories, the dimensions involved, the classification of the driver, the internal and external conditions of the peasant units that interfere in the transition process, and the impacts of the agroecological transition process for peasant families. Specifically, the articulation among cosmovision and identity, collective knowledge building, organizations at regional and national levels, political engagement, and nature-based technical solutions led countless families to promote and practice agroecology.

## 1. Introduction

The debate on sustainability in agriculture started in the second half of the 20th century to counter the negative environmental and socio-economic effects of the “Green Revolution”, the technological basis of so-called modern agricultural systems. Examples of these effects include water pollution by pesticides, soil degradation, the effect on human and non-human health (Carneiro et al., 2009), and the public financing costs of an unsustainable production logic that receives the lion's share of investments, concentrates wealth in transnational industrial conglomerates producing agricultural inputs (Pelaez et al., 2015), and widens social inequality.

Efforts have been made to develop sustainable agricultural systems using a transition process based on agroecological principles (Gliessman, 2009), applied to and beyond farm level (Barrios et al., 2020). At farm level, these principles include, among others, nutrient cycling, biodiversity synergies, soil and water conservation, use of renewable-energy sources, and respect of local knowledges (Gliessman and Agroecology, 2015). However, processes and elements that go beyond the farm level are equally important, such as global responsible governance and circular and solidarity economy (Barrios et al., 2020). The application of agroecological principles faces challenges on higher levels, such as the lack of governmental public policies and the lack of adequate technical assistance to restore degraded environments (Molina Navarro, 2015). Efforts to overcome such challenges have been made by various social actors (Giddens, 2009; Giddens, 1979), including peasant communities and scientists, working in dialogical partnership. Understanding the drivers of the actions developed by these social actors can bring to light key elements capable of promoting, through agroecological principles, more sustainable agrifood systems.

Many of the agroecological principles are derived from the understanding of agroecology as a science, practice, and social movement, in an integrated and articulated form (Wezel et al., 2009; Associação Brasileira de Agroecologia, 2015) to develop sustainable agrifood systems in their ecological, economic, and social dimensions (Associação Brasileira de Agroecologia, 2015; Gliessman and Agroecology, 2015). As a science, in Brazil, agroecology is built on principles and methods from a systemic perspective and as a practice experienced, recreated and transmitted by peasants in different contexts (Favero and Pacheco, 2013). Taking agrifood systems as the basis for studying agroecology implies understanding agroecological practices in a broad way, not limited to food production. Agroecology also encompasses food processing, circulation, distribution, and consumption (Gliessman and Agroecology, 2015), and the recycling of organic residues that feed back into the system. As a movement and practice, cultural and political dimensions are incorporated into the understanding of agroecology. Culture and politics are essential to build the institutional environment for the necessary transformations towards sustainable agrifood systems (Gomes, 2020; Goris, 2020; Teixeira, 2020; Van den Berg, 2020). In Brazil, the transition to agroecology is materializing in various environments and socio-economic contexts, with a broad diversity of expressions, perceptions, and perspectives, from a wide range of

organizations and social networks. This process permeates, more and more, into the academic scientific institutions and puts itself firmly in the political debate by pointing out sustainable options for agriculture.

By some authors, agroecological transition is also understood as steps to be taken that lead to the reduction of use of industrial inputs, the replacement of these inputs by organic inputs, the redesign of agroecosystems and, finally, the transformations of the agrifood system (Gliessman and Agroecology, 2015). However, the transition pathway is not a linear process (Gaitán-Cremaschi et al., 2020). Moreover, the reduction of industrial inputs and the input substitution can be, by other authors, considered agroecological but still maintain the dependency of farmers upon purchase of products (Mier Y Terán et al., 2018).

In line with Anderson et al. (2019), we understand agroecological transition as a continuous process based on core principles that inform agroecology in the social, cultural, environmental, economic, and political dimensions. Therefore, agroecological transitions must be understood as a complex movement of incorporation of ecological and social principles in the management of agroecosystems and in the development of agrifood systems that mobilize multiple dimensions of social life, confronts worldviews, forges identities, and activates processes of conflict and negotiation between different actors. In this way, the transition can be understood as a construction that emerges through interactions established between actors, natural assets, activities, and places in rural development processes (Schmitt, 2009, p. 178).

Analyses regarding agroecological transition (Côte et al., 2019; Magrini et al., 2019) identified gaps and drivers (Mier Y Terán et al., 2018; Côte et al., 2019). These analyses demonstrated knowledge gaps such as: (i) the lack of studies that analyze complex long-term agroecological transition processes; (ii) the lack of knowledge about which drivers are most important to expand agroecological transitions; and (iii) the scarcity of studies that make an interdisciplinary reflection on the agroecological transition process (Teixeira, 2020).

In the transition process, different drivers (Hazell and Wood, 2008; Mier Y Terán et al., 2018; Côte et al., 2019; Magrini et al., 2019) are responsible for socio-ecological transformations (Molina Navarro and Toledo, 2014). The drivers are actors, elements or core promoting factors of transformations emerging from the relationships between human groups and between human groups and the environment, mediated by techniques involving knowledge and intentionality (Santos, 2002). In processes of agroecological transition, the drivers create conditions, motivate people to change their conventional agricultural practices for agroecological practices, and promote the transition in the ecological, social, cultural, political, and economic dimensions. Often, the transition is the (synergistic) result of the interaction and integration of several drivers (Mier Y Terán et al., 2018).

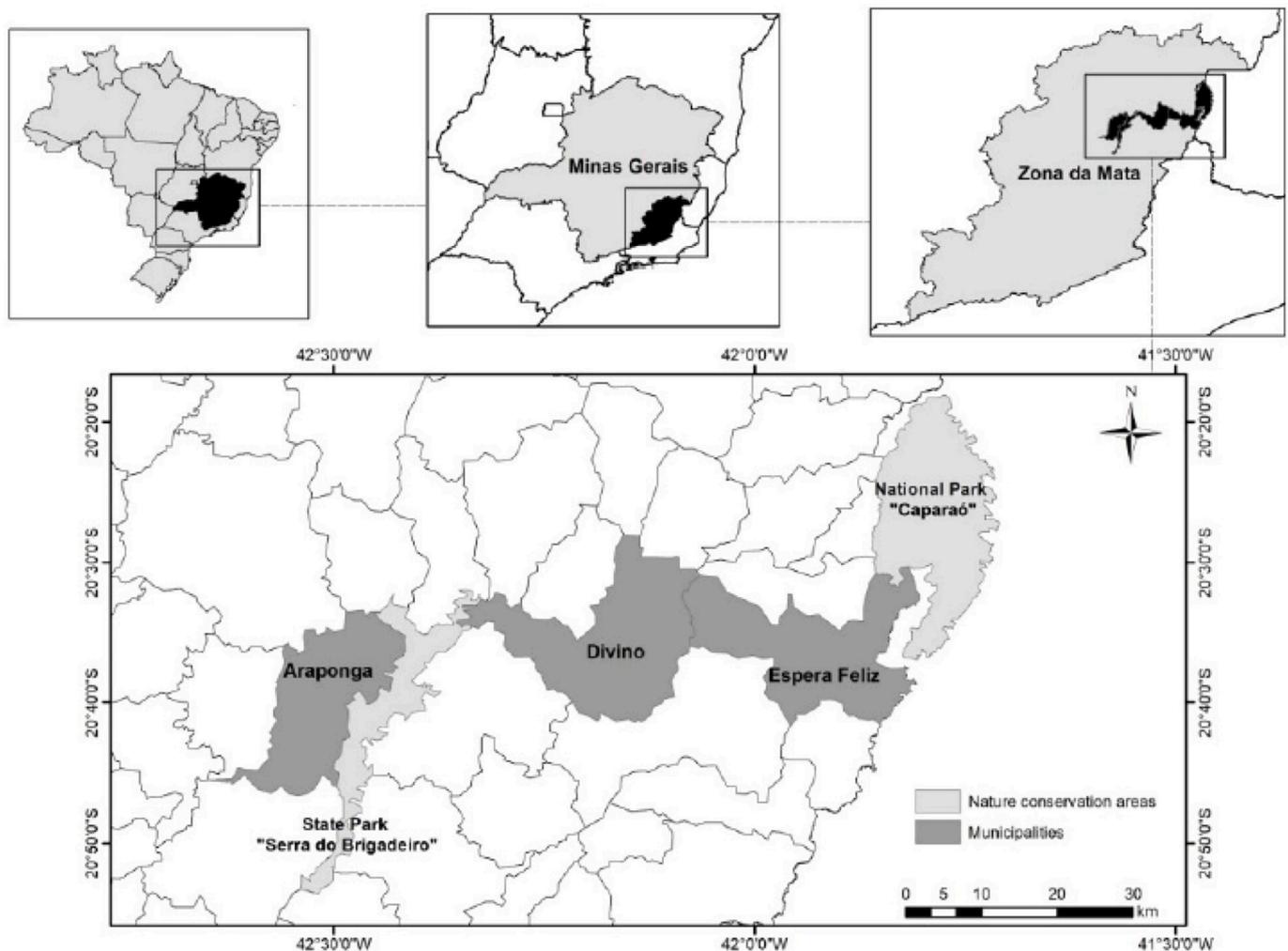
Understanding the drivers can contribute to expanding the agroecological transition and should be based on studies that use quantitative and qualitative methods, appropriate for the analysis at different scales, comprising social and ecological aspects in the places where they occur (Gomes, 2020; Teixeira, 2020). When it comes to experiences of peasant studies, researchers should seek to identify and analyze how the drivers act and why they cause transformations that lead numerous

families to promote and practice agroecology; the internal and external conditions of family units (family property) that interfere in transition processes; and the impacts of the agroecological transition process for peasant families and for the region where it occurs.

Earlier studies have identified several transition drivers as well as mechanisms that blocked or delayed such transitions. [Hazell and Wood \(2008\)](#) developed a country × farming systems typology (but without a specific focus on agroecology) to explore linkages between human needs, agriculture, and the environment. In their analysis they did not address the role of social movements in enhancing the agroecological transition. [Molina Navarro and Toledo \(2014\)](#) introduced the concept of social metabolism, distinguishing between tangible and intangible metabolic processes. Their study focused on socio-ecological transformations but provided little detail of specific agroecological transformations. [Mier Y Terán et al. \(2018\)](#), in an analysis of five case studies that included an agroecological network in southern Brazil, identified eight drivers and emphasized the importance of positive feedbacks and synergisms among the drivers. They made a plea for the need of more detailed understanding how their eight drivers interact. [Côte et al. \(2019\)](#) equally provided a multi-level perspective. They noted four critical drivers that in southern Brazil unlocked the dominant socio-technical system of conventional agriculture. While their analysis included policy support, the role of social movements was hardly mentioned. [Magrini et al. \(2019\)](#) provided a general overview of agroecological transitions and the factors that cause a lock in, emphasized

the importance of deliberate political action to unlock the dominant socio-technical system, but did not provide detailed case studies to underpin their conclusions. [Anderson et al. \(2019\)](#) noted that multilevel perspectives on agroecological transformations often devoted too little attention to bottom-up processes initiated by social movements. [Schiller et al. \(2020a, 2020b\)](#), equally using multilevel perspectives, focused on barriers hindering the agroecological transition in Nicaragua with a major role for the dominant socio-technical regime blocking the agroecological niche. Finally, [Vermunt et al. \(2022\)](#), in a study on Dutch dairy systems noted the major role of blocking mechanisms that hindered an agroecological transition, which ultimately was due to the dominant productivist socio-technical system dominating agriculture in the Netherlands.

Our study expands on those earlier studies. Based on more than four decades of experiences in Zona da Mata, Minas Gerais, Brazil, we provide a more in-depth analysis of drivers of the agroecological transition that has taken place (and is still taking place) since the 1980s. We recognized 29 drivers, classified in five dimensions. We furthermore specify and deepen the analyses of the drivers' dimensions, synergies and interdependences to better understand the transition process with multiple cause-effect nexus considering internal and external forces of the context. Our purpose is to understand the role and capacity of drivers to foster agroecological transition processes. The specific objectives are: i) to identify the drivers and their relationship with the multiple dimensions of the context in which they occur; ii) to understand how and



**Fig. 1.** The Zona da Mata in the state of Minas Gerais, Brazil. The three studied municipalities (Araponga, Divino and Espera Feliz) form a corridor between The Serra do Brigadeiro State Park and Caparaó National Park (Source: [Teixeira, 2020](#)).

why the drivers transform this context and; iii) to assess which internal and external conditions influence the agroecological transformations. The transitional process started 40 years ago and involved different actors, institutions, and scales of transformation. The analysis is important because studies on experiences of such duration and density are scarce and may point out challenges and solutions that will likely be relevant in the transition to agroecology elsewhere.

## 2. Methodology

### 2.1. Description of the study area

The Zona da Mata, in Minas Gerais, Brazil (Fig. 1) is situated in the Atlantic Forest Biome, considered the fifth hotspot of biodiversity and one of the most threatened and biodiverse ecosystems in the world (Myers et al., 2000). Currently, the remnants of the Atlantic Forest occupy 24 % of the region and are mainly found at the highest portions of the landscape (Gomes, 2020). The Serra do Brigadeiro State Park and Caparaó National Park (Fig. 1), are important environmentally protected areas that preserve the remnants of the Atlantic Forest in the area. The Zona da Mata of Minas Gerais has a (strongly) undulating relief, with altitude ranging from 200 to 1800 m above sea level (Golfari, 1975). It has a Cwa climate (a subtropical climate with dry winters and hot summers), according to Köppen's classification, with an average temperature of 19 °C, rainfall of 1300 mm, and a dry winter of two to four months (Golfari, 1975). The most common soils are classified as Oxisols (Empresa Brasileira de Pesquisa Agropecuária, 2024), which are deeply weathered, well-drained, low concentration of nutrients and acidic. In many cases, these soils, as well as the water resources, have been degraded by intense exploitation and their recovery is a major challenge.

The region was originally occupied mainly by the Purí indigenous ethnic group, with Europeans and Africans arriving at the end of the 17th century. The African descendants were enslaved in the gold mines near the region and sought land and refuge in the Zona da Mata after abolition (Lamas, 2013), and, in some cases, prior to abolition. The ethnogenesis of the peasantry that currently inhabits the region stems from the Purí people, enslaved Africans, and European migrants. From a colonial perspective, which disregards the presence of the original peoples, the occupation process of the region occurred in an incipient way from the 18th century, with the formation of productive units focused on polyculture and animal husbandry. Occupation was intensified from the 19th century, with the development of coffee monocultures and, later, extensive pastures for cattle (Carneiro and Matos, 2010). The land use under the colonial perspective generated large deforestation and the capital accumulated through agricultural activities was designated for the establishment of industry and road infrastructure for the flow of agricultural production (Netto and Diniz, 2005).

In the Zona da Mata, 75.5 % of the farms are owned by peasants, who occupy 40 % of the total land (Instituto Brasileiro de Geografia e Estatística – IBGE, 2017). Of Brazilian states, Minas Gerais has the second most family-farming establishments, with the Zona da Mata being the region with the third most family-farming establishments in the state (Instituto Brasileiro de Geografia e Estatística – IBGE, 2017). Most of the land in the central portion of the Zona da Mata (surrounding the Serra do Brigadeiro) is occupied by pastures (56 %) and coffee (11 % of the area). The pastures are covered by monocultural exotic grasses (mainly *Brachiaria* sp.) that support cattle herds for milk and beef production (Gomes, 2020). They are generally exploited through monoculture, with extensive use and without the use of fertilizers to replace the extraction of nutrients from the soils. Higher altitudes allow the cultivation of arabica coffee (*Coffea arabica*), which achieves higher beverage quality than robusta coffee (*Coffea canephora*) and, consequently, higher marketing value (Gomes, 2020). Coffee is considered the cash crop in the region and is cultivated predominantly in full-sun monoculture (Instituto Brasileiro de Geografia e Estatística – IBGE, 2017).

Coffee monoculture follows the patterns of agricultural modernization, with the use of modified seeds, synthetic fertilizers, and pesticides, although the landscape does not allow for mechanization and large-scale irrigation. Coffee is transported by road and exported via ports to the neighboring states of Rio de Janeiro and Espírito Santo (Netto and Diniz, 2005), which means that much of the wealth generated by the production of this commodity accumulates in other national and international regions, where coffee is also primarily processed. To counteract this wealth export process, since the beginning of 2000s there has been an effort to produce quality coffee with a focus on direct marketing to consumers (Netto and Diniz, 2005). Beyond coffee and dairy farming, peasants in the region are very diversified with the production of sugarcane, corn, beans, vegetables, fruits, pork, and poultry, among other small animals and crops. The diversified production is important for food security and sovereignty of the families. The surplus of this diversified agricultural production is commercialized in the region, supplying the domestic market and generating monetary income for the families.

In addition to the ample agrobiodiversity, there is also a great diversity of social organizations, ancestral knowledges on the management of natural resources (Fernandes, 2020), and traditional peasant practices. Since the 1980s, in the northern portion of the Zona da Mata, this diversity was the basis for a process of social and grassroots mobilization that began to question the effects of the use of chemical inputs, especially fertilizers and pesticides, in coffee plantations, due to their negative impacts on the health of humans and non-humans, waters and soils. This mobilization contributed to the process of agroecological transition. In the northern portion of the Zona da Mata, approximately 30 % of the studied peasants were considered agroecological according to a quantitative cluster analysis based on farm structural and functional variables conducted with a representative sample of 115 peasants (Teixeira, 2020). A similar proportion of agroecological peasants was mentioned by peasants in three participatory workshops conducted in different municipalities (Teixeira, 2020).

The process of agroecological transition resulted in differences in terms of management techniques, practices, and strategies as well as objectives and values (Teixeira, 2020). The techniques and practices utilized by agroecological peasants include animal and plant breeding, agroforestry systems (Gomes, 2020; Goris, 2020; Teixeira, 2020; Van den Berg, 2020), certified organic coffee, no-till cultivation, soil cover, compost and biofertilizers, green manure, mechanical weed management, biological control of animals and plants, use of various homemade products for pest and pathogen control, selective mowing and rotation of pastures, consortium of crops, use of locally adapted landrace seeds, conservation of forests and water resources, and recycling of residues (Teixeira et al., 2018a). However, not all peasants utilize all those practices. For example, agroforestry systems and certification of organic coffee are not used by everyone. At the same time, agroecological practices can also be adopted to some extent by conventional or traditional peasants, indicating that the transition process can be understood as continuum, with fuzzy and complex boundaries between farm types (Teixeira et al., 2018a). The development of agroecology also involves the encouragement of direct marketing and other perspectives on social relations, including gender and youth, with robust social organization (Teixeira et al., 2018a; Goris, 2020). Due to the robustness and importance of the agroecological transition processes in the region, in 2018, Zona da Mata was considered by the state government the first Hub of Agroecology and Organic Production in Brazil (Minas Gerais Law 23.207/2018).

### 2.2. Data collection and processing

The present study was developed from a literature review on the geobiophysical, historical-geographical, economic, and demographic aspects of the Zona da Mata and four doctoral theses (Gomes, 2020; Goris, 2020; Teixeira, 2020; Van den Berg, 2020) carried out in the region between 2015 and 2020, as part of the international research

program entitled *Nature's Benefits in Agro-forest Frontiers: linking actor strategies, functional biodiversity, and ecosystem services* (FOREFRONT; available at <https://www.wur.nl/nl/project/FOREFRONT.htm>, accessed on Oct. 25, 2022). This program was set up by a consortium formed by Wageningen University (WU-the Netherlands), Federal University of Viçosa (UFV-Brazil), Universidad Nacional Autónoma de México (UNAM-Mexico) and El Colegio de La Frontera Sur (ECOSUR-Mexico). In Brazil, the studies were conducted in three municipalities (Araponga, Divino, and Espera Feliz, Fig. 1) in the northern portion of the Zona da Mata by WU and UFV, in partnership with the non-governmental organization Center for Alternative Technologies of the Zona da Mata (CTA-ZM) and peasant organizations that have promoted agroecological transition in the region since the 1980's. The three municipalities connect the Serra do Brigadeiro State Park and Caparaó National Park (Fig. 1). The studies executed by the FOREFRONT program focused on the processes of transformation that have taken place in the central area of Zona da Mata (around the Serra do Brigadeiro) in the last 40 years and, therefore, are important sources for the analysis of drivers.

Gomes (2020) used satellite images, participatory workshops with social actors, and bibliographic data from historical records to study land use and land cover (LULC) changes. In the LULC analysis, the associated socio-economic factors (environmental and agricultural credit policy) and their effects on agroecosystem services were analyzed. Eight key indicators (carbon, habitat, pollination, water flow regulation, soil erosion control, coffee production, animal production, and cultural services) were used, with special attention to water and coffee production. In the analysis, Gomes (2020) considered the projected effect of climate change over the next three decades. The forecast is that the increase in the region's average temperature will lead to a reduction of almost 60 % of the area currently suitable for full sun coffee production by 2050 (Available at: <https://www.ipcc.ch> accessed on Nov, 02, 2022).

Teixeira (2020), analyzed the interaction between biodiversity, agroecosystem services, and social actors, with focus on the soil-vegetation relationship, and considered the processes of agroecological transition in its social, environmental, institutional, and political aspects. The analysis involved the measurement of 41 management, biodiversity, soil quality, and productivity variables identified from the characterization of 12 coffee fields and 12 pastures; the analysis of data collected on 115 farming systems; the construction of 24 cognitive maps on peasant's perception of ecosystem services; 24 semi-structured interviews with agroecological and conventional peasants; and the measurement of 23 indicators of forest diversity, as well as biological, chemical, and physical soil quality in 12 forest fragments of different ages. In addition, over 10 participatory workshops were organized to co-create, present, discuss, and validate research results with peasants.

Van den Berg (2020) analyzed 25 semi-structured interviews and was a participant observer in 15 meetings, known locally as "agroecological exchanges". He also analyzed, in the field, the agroecological production practices carried out by five families, in the three municipalities where the research was carried out; the relationship of these practices with peasant strategies in the creation of greater autonomy and sustainability; the relationship of the agroecological movement in the Zona da Mata and the Brazilian national movement, with attention to the role of affective relationships between the actors in this process; the relationship between this movement and resistance and existence in the midst of social struggles waged within the scope of hegemonic society, such as the adoption of the Green-Revolution package widely used in the area; and changes in the broader institutional environment.

Goris (2020) analyzed the construction of youth identity in the three municipalities, their relationship with agroecology on the land, in the social organizations of peasants and in the spaces of popular and formal education. The research considered feminism and ethnicities expressed in the indigenous and Afro-descendant movement; social-gender relationships, with emphasis on the relationship between women and youth with emancipatory practices; and the logic of peasant resistance

and social transformation with special attention to youth and their challenges to engage in transformative changes towards agroecology. To this end, she carried out ethnography using audiovisual resources (known as ethnovideography) with 41 young people, and participant observation in six agroecological exchanges and in several meetings of youth social movements, including students from the Puris Family Agricultural School (EFA), in Araponga.

Moreover, to define the analytical focus and to deepen the reflections on the drivers, besides the Forefront Program, five semi-structured interviews were carried out by the first author of this study, one with each of the researchers who worked in the region, and one with the regional coordinator of Forefront. Participant observation was also carried out by the first author at a regional gathering, called *Troca de Saberes*, held in August 2022, with the participation of several actors directly involved in the agroecological transition process in the region (Available at: <https://www.instagram.com/trocadesaberesufv/?hl=en>, accessed on October 20, 2022).

### 2.3. Actors involved with the study

The actors involved directly in the agroecological transition process in the area are the peasants and their civil organizations, such as associations, cooperatives and unions of rural workers and peasants, and religious groups, such as the Basic Ecclesial Communities and pastoralists, of which the peasants are part of; CTA-ZM advisors; and students, professors and researchers from the Federal University of Viçosa (UFV). These actors are inserted in networks of organized civil society and in regional, state, national, and international articulations that interact with municipal, state, and federal public authorities of the executive and legislative branches to influence public policies aimed at supporting agroecology and peasants.

### 2.4. Identification of drivers that promote or hinder agroecological transition

Drivers are understood as actors, elements, or factors that promote or drive transformations – from the relationship between groups of humans to between groups of humans with the environment. This relationship is mediated by techniques, knowledge, and intentionality (Santos, 2002). Actors are individuals, who operate actively within a social structure, like organizations or institutions; elements are related to the environment, for instance, water, climate, and relief; and factors are related to processes, such as laws and public policies. The actors participate in the formation and transformation of the organizations or institutions. The elements and factors affect or promote directly the transformation.

Initially, the four theses (Gomes, 2020; Goris, 2020; Teixeira, 2020; Van den Berg, 2020) were analyzed and the drivers, the transformation generated by said drivers, and the dimension of the transformation were identified using an analytical framework. The framework consisted of analyzing which actors, elements, or factors (drivers) generated transformations, in understanding the transformation generated and in categorizing the drivers into five agroecological dimensions (social, cultural, environmental, economic, and political). These dimensions are somehow always linked to the theoretical basis of agroecology (Hecht, 2002) and are part of the reality of the relationships of humans among themselves and with the environment, for physical reproduction with symbolic references (Haesbaert, 2007). Often, changes in one dimension led to changes in the other dimensions. The drivers were organized according to these five dimensions.

In the identification of the drivers, we also considered how the internal and external conditions of the peasant families interact with the drivers and therefore impact their livelihood. This corresponds to the way a given social group manifests its life and concerns the set of daily practices developed. Such practices are the result of history, the position the group occupies in society, and the specific way that it ensures the social reproduction of the group (Marques, 1994). In the case of the

peasants, their livelihood is formed by family, neighbors, forms of organization of immediate production, living and working conditions, as well as political and religious relations, which are based on a set of [cultural] values that give them meaning (Marques, 1994). Thus, internal conditions refer to those that the family has greater decision-making power over; and external conditions refer to those where the individual family has no decision-making power but can contribute to decision-making from their engagement in social processes. Some conditions can be described as both internal and external.

Moreover, we classified the drivers (subject, elements or factors) as basic, foundational and structural according to their role in the transformation process. The basic drivers are the subject, elements or factors without which the transition cannot take place, such as land and water access. Foundational drivers refer to the socio-cultural principles and values that guide transition practices, for example cosmovisions (worldviews) that inform that the forest should be conserved because it is sacred or that trees are important in the crop fields. Structural drivers are those that facilitate and extend the transition process, such as public policies in favor of agroecology.

The drivers, organized according to the five dimensions, are linked to the generated transformations, to their internal and external conditions, and to their classification as basic, foundational, or structural characteristics. For each driver, the bibliographical references that allowed identification and classification are indicated.

### 3. Results

In total, 29 drivers of agroecological transition are recognized and grouped according to their effects on the social (7), cultural (5), environmental (8), economic (5), and political (4) dimensions. These drivers were analyzed considering a period of more than 40 years, during which main events accelerated or decelerated the transition (Fig. 2). A summary of these drivers, linked to the transformations generated, whether internal or external, and literature that determined their identification is found in Tables 1 to 5.

#### 3.1. Social drivers

This dimension (Table 1) refers to the organization and social participation in institutions, groups and networks, and the social relations of gender and generation between the actors and the relationship or influence of these actors in the agroecological transition process. The social organization of work was a basic driver in the agroecological transition. Agroecological peasants depended on family and community

work to provide the workforce for agroecological production. The family organized itself to enable social practices of exchanging workdays between families and guaranteeing the necessary workforce.

Participation in organizations and social movements promoting agroecological transition is a structural driver for agroecological transition. Non-governmental organizations (NGOs), rural workers and peasant unions, community associations, cooperatives, collectives, consumer groups, and networks are all part of these organizations and movements promoting agroecology. The agroecological peasants are members of rural worker's associations and unions, and participate in groups such as grassroots ecclesial communities and pastoral groups of the Catholic Church. These peasants had easier access to public policies, which favored the agroecological transition processes. There was a relationship between peasants who made the agroecological transition and access to public policies, including extension projects. Among the agroecological peasants analyzed, 100 % participated in CTA-ZM and UFV projects and had access to some type of public policy. This participation made it possible for peasants, technicians, and scientists to co-create agroecological knowledge, such as the design of agroforestry systems and the valuing of the potential of local seeds.

The co-creation of agroecological knowledge is another structural driver of the agroecological transition. The processes of action research and experimentation with the collaboration of peasants, technical advisors, and researchers, as well as the agroecological exchanges between all those involved and agroecological training meetings, were considered fundamental for the co-creation of knowledge and useful for the agroecological transition.

Popular and formal rural education initiatives are foundational drivers and have been promoted in the region by local social movements based on the theoretical and methodological foundations of popular education. These initiatives have encouraged forms of critical education based on local reality and have been identified as driving the engagement of young people in the agroecological transition process. The young people got involved with the agricultural family schools, union schools, the Catholic Church's youth ministry and the degree course in Rural Education (at UFV).

The involvement of these young peasants in the agroecological movement was identified as a foundational driver in promoting agroecological transition, since they, as the new generation, give new meaning to agroecology. Young people have directly influenced the family's management practices towards transition, thanks to critical educational processes based on agroecology. The young people themselves created and organized educational processes that broadened social diversity and the participation of other youth groups in the

## AGROECOLOGICAL TRANSITION TIMELINE

In the Zona da Mata, Minas Gerais, Brazil

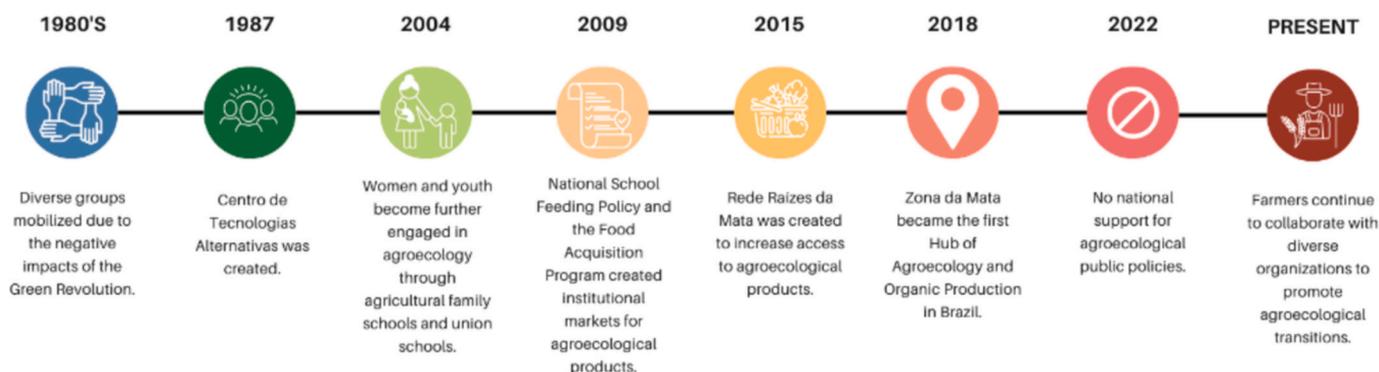


Fig. 2. Timeline of the agroecological transition in the Zona da Mata.

**Table 1**

Drivers related to the social dimension that have promoted or hindered the agroecological transition that has been underway for 40 years in the Zona da Mata.

Drivers	Transformations generated	Internal (I) and External (E) Conditions	Basic (B), Foundational (F) or Structural (S) drivers <sup>1</sup>	Bibliographical References
Social organization of work	Availability of labor for production	Availability of family and community workforce and the conditions or means to carry out this work (I)	B	Teixeira et al. (2018a); Teixeira (2020)
Participation in social organizations and movements	Access to information and public policies, including extension projects that promote transition	Social organizations committed to agroecology (I and E) and willingness to participate (I)	S	Teixeira et al. (2018a); Gomes (2020); Goris (2020); Teixeira (2020); Van den Berg (2020)
Co-creation of agroecological knowledge	Understanding of useful transition processes	Social organizations engaged with agroecology (I and E) and institutions promoting agroecological knowledge (E). Willingness to participate in events (I)	S	Teixeira et al. (2018a, 2018b); Gomes (2020); Goris (2020); Teixeira (2020); Van den Berg (2020)
Popular and formal rural education initiatives	Access to critical education appropriate to the needs of the countryside Involvement of young people in the agroecological transition process	Social organizations engaged in agroecology (I and E) and access to education appropriate to the needs of the countryside (E)	F	Goris (2020)
Youth	Increased permanence of young people in the countryside, with a large active role in the transition and agroecological processes	Agroecological organizations and movements that promote youth engagement and struggles against various prejudices (I and E) and willingness to participate (I)	F	Goris (2020)
Gender	Increased role for women and greater conservation of agrobiodiversity	Agroecological organizations and movements that promote a break with chauvinist patterns of power (I and E) and willingness to participate in the movement (I).	F	Teixeira et al. (2018a); Goris (2020); Teixeira (2020)
Collective political influence (local, regional and national)	Access to information and public policies that drive the transition	Network of social organizations promoting agroecology (I and E) and engagement in struggles for agroecological public policies (I).	S	Teixeira et al. (2018a); Gomes (2020); Goris (2020); Teixeira (2020); Van den Berg (2020)

<sup>1</sup> Basic: without them the transition cannot take place; foundational refer to the socio-cultural principles and values that guide transition practices; structural: facilitate and extend the transition process.

**Table 2**

Drivers related to the cultural dimension that promoted or hindered the agroecological transition conducted for 40 years in Zona da Mata.

Drivers	Transformations generated	Internal (I) and External (E) Conditions	Basic (B), Foundational (F) or Structural (S) drivers <sup>1</sup>	Bibliographical References
Peasant cosmivision	Reframing values and practices in favor of transition	Existence of peasantry and agroecological social movements (I and E)	F	Teixeira et al. (2018b); Goris (2020); Teixeira (2020); Van den Berg (2020)
Peasant identity	Carrying out management practices and collective work in favor of transition	Existence of peasantry (I)	F	Teixeira et al. (2018a, 2018b); Teixeira (2020)
Ancestral knowledge	Diversification of agroecosystems and an increase in the provision for natural benefits	Existence of peasantry with ancestral knowledge (I)	F	Teixeira et al. (2018a, 2018b); Teixeira (2020)
Affective work	Incorporation of new agricultural, community, and market practices for the transition process	Meanings attributed to agroecology in line with local social values for the social mobilization of other peasants for the transition (I)	F	Goris (2020); Van den Berg (2020)
Agribusiness ideology	Promotion of critical reflection on the harmful effects on the health of humans and non-humans, which strengthened the transition	Propagation of agribusiness ideology among peasant communities (E)	F	Van den Berg (2020)
Adapted technique	Facilitating work and adapting to local soil and climate conditions	Existence of social organizations engaged in agroecology and institutions promoting agroecological knowledge and its socialization (I and E)	S	Teixeira et al. (2018a); Van den Berg (2020)

<sup>1</sup> Basic: without them the transition cannot take place; foundational refer to the socio-cultural principles and values that guide transition practices; structural: facilitate and extend the transition process. The drivers were considered either foundational or structural in the environmental dimension.

agroecological movement, influencing the transition in the region. They reworked local culture, making the regional agroecological movement more inclusive, facilitating the participation of different populations, sexualities, generations, and genders, and promoted interconnection between humans and non-human nature. Young people from different municipalities were involved in such actions, which facilitated the transition process on a regional scale.

Gender relations, especially the role of women in the home gardens and their commitment to agroecology, was a foundational driver in the agroecological transition process. Women's involvement in the agroecological movement and in debates on feminism helped strengthen the importance of women in agroecology, making them active actors in the transition. The participation of young people and women also

contributed to the emergence of political platforms for and by them at local, state, and national levels.

Collective political advocacy was a structural driver that made it possible for public policies to exist in favor of the agroecological transition, some specifically for young people and women. Social movements and the National Articulation of Agroecology (ANA) favored this advocacy. ANA is the network of movements that articulates the struggle for agroecology in Brazil. The participation of social organizations in the Zona da Mata region in state and national organizations, such as ANA, and in social movements was fundamental for access to public policies and to promoting connections. Such participation has facilitated access to information and advice on drawing up projects supported by these policies.

**Table 3**

Drivers related to the environmental dimension that promoted or hindered the agroecological transition conducted over 40 years in the Zona da Mata.

Drivers	Transformations Generated	Internal (I) and External (E) Conditions	Basic (B), Foundational (F) or Structural (S) drivers <sup>1</sup>	Bibliographical References
Geobiophysical characteristics	Greater use of trees, common in the Atlantic Forest biome, to promote soil conservation on slopes and nutrient cycling in weathered soils	Geobiophysical characteristics (E), ancestral knowledge (I), existence of institutions promoting agroecological knowledge and its socialization (I and E) and willingness to participate (I)	S	Teixeira (2020); Van den Berg (2020); Teixeira et al. (2021)
Externalities of the Green-Revolution technology	Decision for transition based on understanding and critical reflection on externalities	Externalities caused by agribusiness (E), existence of social organizations engaged in agroecology (E and I)	F	Teixeira et al. (2018b); Teixeira (2020)
Biodiversity management	Re-establishment of social relations between humans and non-humans, increased functionality of agroecosystems and the landscape, greater diversification of production, income, and improved nutrition	Existence of conserved flora (I and E), management of locally adapted agrobiodiversity (I), and decision to participate (I)	B and S	Gomes (2020); Goris (2020); Teixeira (2020); Van den Berg (2020); Teixeira et al. (2018a, 2018b, 2021)
Soil and water conservation	Greater conservation and increased soil and water quality through the management of biodiversity, especially trees, and reduced use of external inputs	Ancestral knowledge (I), existence of institutions promoting agroecological knowledge and its socialization (I and E) and decision to participate (I)	B	Teixeira (2020), Teixeira et al. (2021)
Agroecological management	Increased biodiversity, maintaining biological, chemical and physical soil quality, maintaining coffee productivity, and increasing soil microbial biomass	Use of agroecological management practices that make it possible to redesign the agroecosystem (I); ancestral knowledge and decision to participate (I)	S	Teixeira (2020), Teixeira et al. (2021)
Forest fragments (presence)	Faster recovery of biodiversity and soil functions, with increased ecosystem services	Existence of conserved flora near the production units (I and E)	S	Teixeira (2020), Teixeira et al. (2020)
Climate	Greater understanding of the importance of agroforestry systems in reducing the temperature in coffee plantations in order to keep them productive in the face of predicted climate change	Climate change (E) and the decision to use trees to mitigate its effects (I)	S	Gomes (2020), Teixeira et al. (2018b), Teixeira et al., (2020)

<sup>1</sup> Basic: without them the transition cannot take place; foundational refer to the socio-cultural principles and values that guide transition practices; structural: facilitate and extend the transition process.

**Table 4**

Drivers related to the economic dimension that promoted or hindered the agroecological transition conducted over 40 years in the Zona da Mata.

Drivers	Transformations Generated	Internal (I) and External (E) Conditions	Basic (B), Foundational (F) or Structural (S) drivers <sup>1</sup>	Bibliographical References
Financial resources	Provided financial investment to structure the transition	Possibility of financial support for the transition from NGOs (E) Existence of specific national credit policies for agroecological production (E)	S	Gomes (2020); Van den Berg (2020)
Price of external inputs and commodities (coffee)	Search for alternatives to provide inputs more autonomously	Prices of inputs and coffee controlled by the international commodities market (E). Agroecological management practices that make it possible to redesign the agroecosystem (I); ancestral knowledge and willingness to participate (I)	S	Van den Berg (2020)
Price and quality of food	Resumption of the practice of producing their own food in conjunction with coffee and greater adherence to agroforestry systems	Food price dynamics on the international market (E), national supply policies (E) and access to local and regional marketing networks for diversified products (E and I)	S	Van den Berg (2020)
Short-circuit food supply chains	Increased income from the sale of diversified products in agroecological consumer networks organized in the region and access to the institutional market.	Social organizations committed to agroecology (E) Existence of national policies for acquiring food from peasants (E)	S	Teixeira et al. (2018a); Van den Berg (2020)

<sup>1</sup> Basic: without them the transition cannot take place; foundational refer to the socio-cultural principles and values that guide transition practices; structural: facilitate and extend the transition process. All drivers were considered structural in the economical dimension.

### 3.2. Cultural drivers

This dimension (Table 2) refers to the social values, cosmovisions, and socially attributed meanings and their relationship or influence on the agroecological transition process. In the Zona da Mata region, peasant cosmovision guides the relationship with nature, which has to be respectful and careful. In the peasant cosmovision, nature cannot only be seen as a source of natural resources. This cosmovision was identified as the foundational driver of the transition, as it guided

management practices towards strengthening and conserving natural assets through biodiversity, by promoting versatile and diversified agriculture. Participation in organizations and social movements active in the region strengthened peasant cosmovision, based on the collective construction of a narrative about agroecological agriculture and the understanding of the need to take care of local natural assets, especially biodiversity, water, and soil. Agriculture was then reconceptualized in local agroecosystems and these were regenerated and enriched by increasing and managing biodiversity, which was reflected in soil and

**Table 5**

Drivers related to the political dimension that promote or hinder agroecological transition, identified in research carried out in the Zona da Mata.

Drivers	Transformations Generated	Internal (I) and External (E) Conditions	Basic (B), Foundational (F) or Structural (S) drivers <sup>1</sup>	Bibliographic al References
Land access	Greater access to land through public policies or not, which increased autonomy to start the agroecological transition on family land	Land structure (E) Land ownership (E and I) Capacity for local organization (I) Social relations of gender and generation (I)	B	Teixeira et al. (2018a); Gomes (2020); Goris (2020); Teixeira (2020); Van den Berg (2020)
Agroecological technical assistance	Better technical assistance, through the expansion of services offered by non-governmental organizations	Existence of public policies for peasant agriculture and agroecological transition (E); Capacity for family and local organization (I)	S	Teixeira et al. (2018a); Gomes (2020); Goris (2020); Teixeira (2020); Van den Berg (2020)
Institutional market	Increased diversification on a sustainable basis and greater availability of food culture through government purchases of peasant products	National policies for government procurement of food from peasant agriculture (E)	S	Teixeira et al. (2018a); Gomes (2020); Teixeira (2020); Van den Berg (2020)
Environmental legislation	They were the most influential external drivers of land use change with effects on the regional landscape	National environmental and economic policy and its effect on land use planning (E)	S	Teixeira et al. (2018a); Gomes (2020); Teixeira (2020)
Agricultural credit	Increased areas of coffee plantations, due to the availability of agricultural credit for peasant agriculture, but not necessarily the credit contributed to the agroecological transition.	National economic policy (E)	S	Gomes (2020)

<sup>1</sup> Basic: without them the transition cannot take place; foundational refer to the socio-cultural principles and values that guide transition practices; structural: facilitate and extend the transition process. All drivers were considered basic or structural in the political dimension.

water conservation.

Peasant identity was also a foundational driver of agroecological transition. Agroecological peasants carried out a greater number of agroecological management practices such as polyculture, the use of local and or traditional seeds, and the use and cultivation of medicinal plants. They also participated more in organizations for collective work, had a greater number of elements of peasant culture in their customs, and recognized a greater number of agroecosystem services. Recognizing the importance of peasants' ancestral knowledge, a foundational driver of agroecology, strengthened peasant identity. This knowledge was forged through direct observation of the biodiversity-soil-water relationship and it was recognized and strengthened by the agroecological movement. Another important foundational driver was the mobilization of affection (feelings, passions, grievances, etc.) to engage people and promote the incorporation of new agricultural, community, and market practices into the transition process. Agroecological movements created affection that fosters the development of alternatives, creating spaces where peasants expressed memories, passions, experiences, and other desires that replace dominant or predefined ways of thinking and doing. The movement mobilized these desires through culture to generate new ideas and to engage people in building agroecological practices.

The ideology of agribusiness has been a foundational negative driver of the agroecological transition. Agribusiness is understood here as capitalist ventures in agriculture and livestock under industrial production bases and, in general, based on latifundia. The ideology of agribusiness has been propagated through the media, local farm stores, peasants, universities, researchers, technicians, and some political parties, and has challenged local values and knowledge by promoting individualism and competition. However, dialectically, even if on a smaller scale, agribusiness was also a positive driver of the transition processes in the Zona da Mata, as it instigated the agroecological movement to construct new meanings and reaffirm values through, for example, agroecological exchange meetings, where this ideology was questioned, and new knowledge was co-created using experimentation based on local and scientific knowledges, important to adapt or create new technique for the management of the agroecosystems. For example, the agroecological movement promoted the practice of mechanical weed control, usually done with hand tools, to avoid the use of chemical weeding with herbicides, consistently promoted by agribusiness as

necessary to save work. To replace the use of hand tools and avoid the use of herbicides, peasant organizations have promoted the use of motorized brush cutters for weed control. Peasant cooperatives have played an important role in making motorized brush cutters accessible and in organizing trainings on how to use them.

### 3.3. Environmental drivers

One of the environmental dimensions (Table 3) refers to geobiophysical characteristics and their relationship or influence on the agroecological transition process. Understanding the geobiophysical characteristics, a structural driver, promotes the agroecological transition. Among these characteristics are the steep slopes where coffee is grown, which are more prone to soil erosion, and the presence of trees in the Atlantic Forest biome, which promote soil conservation and nutrient cycling. The understanding of co-genesis of trees and soil conservation in a hilly landscape has driven the implementation of agroforestry systems by peasants in the process of agroecological transition. The diversification of agricultural systems with trees in the system has increased the provision of agroecosystem services.

In a strong way, the perception and recognition of the negative externalities of Green-Revolution technologies drove the agroecological transition and was therefore considered a foundational driver. For instance, peasants' perception of the effects of pesticides, such as contamination of food, water, soil, and air, with negative impacts on human and non-human health, was mobilized by the agroecological movement, which promoted reflection on these effects and contributed to the decision to make the agroecological transition.

Recognizing peasants' ancestral cosmivision and knowledge of environmental aspects were fundamental for peasants to promote biodiversity in their agroecosystems, increasing the provision of benefits from nature, or ecosystem services, and expanding the number of peasant's units in agroecological transition. According to their cosmivision, nature is sacred and diverse. In turn, with more diversification and autonomy, agroecological peasants have a more comprehensive perception of their agroecosystem in terms of matter and energy, as well as the effects of management on ecosystem services, than the conventional peasant. Biodiversity was considered a basic driver to the agroecological transition. Local markets, exchanges or agroecological

thematic meetings, and public policies are important in promoting biodiversity, by providing access to propagation material such as seeds and seedlings, which are essential in transition processes; by allowing a greater understanding of the function of unknown plant species; and by facilitating the trade of diversified production.

Biodiversity is also a basic driver in transition processes due to its role in the functionality of agroecosystems and the landscape, and in generating income, including for women and young people. Trees in particular, generate many benefits due to their associated biodiversity. Agroecological peasants recognized the multifunctionality and benefits of trees in their agroecosystems more than non-agroecological peasants. Agricultural biodiversity, or access to agrobiodiversity, is equally considered a structural driver of the transition. Agroecological peasants had greater crop diversification, leading to greater relative autonomy as they had diversified production systems, little use of external inputs, no use of pesticides, use of local and/or traditional seeds, and adopted innovative agricultural practices. These local seeds are adapted to local soil and climate conditions and are central to food sovereignty. Agricultural biodiversity is also understood as socio-biodiversity, as the fruit of the families' management of biodiversity. Biodiversity management has made it possible to re-establish or build social relations between humans and non-humans and to promote water and soil conservation. Among ecosystem services, guaranteed access to water in quantity and quality was the benefit of nature most mentioned by agroecological peasants. This benefit was always related to soil conservation and biodiversity. Increasing and managing biodiversity were essential to promote water and soil conservation practices, considered basic drivers for the transition.

Agroecological management was considered an essential structural driver of the transition process. And biodiversity management in particular is important for reconciling production with environmental conservation. For example, the coffee crop is suitable for shade, but the amount of shade has to be controlled, which is done by managing the trees. In Zona da Mata, the agroecological coffee management, which includes the presence of trees, led to an increase in biodiversity, which subsequently improved soil quality. The increase in plant diversity from agroecological management was important for maintaining coffee productivity and enhancing soil fertility and soil microbial biomass. In the case of the pastures, agroecological management had a positive effect on biodiversity, with an increase in trees in the pastures that had a positive effect on soil quality, and, consequently, increased soil water availability. Forest fragments were identified as important structural drivers for the transition. The presence of forest fragments near agroecosystems contributed to the rapid recovery of biodiversity and soil functions, and increased ecosystem services, such as water and climate regulation, erosion control, the supply of forest products, and landscape aesthetics.

The perception of climate change is considered a structural driver of the transition process. The average annual air temperature is predicted to increase by  $1.7 \pm 0.3$  °C in the area over the next decades, which directly implies a reduction in the area suitable for coffee production, the region's main agricultural asset. The effects of these changes have already begun to be observed by agroecological peasants and this has strengthened the importance they attach to agroforestry systems. Indeed, the trees, components of these systems, reduce the temperature in coffee plantations and maintain their productivity even with the increase in temperature. Extreme weather events have been observed in the region and are expected to occur more frequently, such as very high rainfall over a short period of time. These events already cause an increase in flooding and landslides in some parts of the region. Agroecological peasant families in the region have great potential to provide benefits to nature, as they have a greater diversity of crops for self-consumption, which has a direct effect on the quality of life of families who have made the agroecological transition. As a result, these families are more resilient to climate change than those who have not (yet) made the transition. This also influences the maintenance of coffee plantations with varieties of higher commercial value in scenarios of

rising temperatures.

### 3.4. Economic drivers

This dimension (Table 4) refers to how the production, income, and markets for agricultural products influence the agroecological transition process. The availability of financial resources to carry out the actions was an essential structural driver for the transition process. This was made possible by public policies via agricultural credit and by organizations such as NGOs that made these resources available.

In the beginning of the process of transition, an important structural driver was the high price of agricultural inputs, especially synthetic fertilizers, and the low price of coffee, a commodity which is an important source of income for peasant families. Without the financial resources and low price of coffee in the international market, there was no money to buy industrial inputs and peasants have looked for more autonomous alternatives that are found in nature. One example is the use of tree residues in agroforestry systems that makes it possible to increase soil fertility. Therefore, lack of money to buy inputs reinforced the agroecological transition, which, in turn, strengthened the autonomy and reduced peasant's dependence on industrial inputs.

The high price and low quality of the food that peasant families bought for consumption was identified as a structural driver that motivated peasants to re-think their economy and the relationship with markets. The agroecological movement mobilized peasants to reflect about their finances and their desire for local quality food, involving them in discussions about the importance of autonomy in relation to food production and commodity markets. Families have repositioned themselves in relation to commodity markets and have resumed the practice of producing their own food in conjunction with coffee. Agroforestry systems were encouraged and became more widespread with the cultivation of fruit trees such as avocado, banana, citrus, and papaya, intercropped with coffee. Additionally, the development of short-circuit food supply chains, such as consumer networks, and the institutional market are an important structural driver to further advance agroecology. In the Zona da Mata region, consumers and peasants organized the "Rede Raízes da Mata", which facilitates access to and marketing of the region's agroecological products. Besides, the peasants' associations and cooperatives, supported by their unions, organized, and mediated access to novel markets, selling to governmental institution like public schools and hospitals.

### 3.5. Political drivers

This dimension (Table 5) refers more broadly to institutional and political aspects and more specifically to public policies and their relationship or influence on the agroecological transition process. Public policies are those organized by the federal, state and municipal governments, through guidelines and the provision of public financial resources that affect the transition in some way. In this dimension, access to land was a basic driver. Access to land allows peasants to decide about their management and use, because without land access, the decision depends on others who own the land. Access to land is challenging to all peasants, but specially for the youth. Many young peasants must leave their communities in search for jobs because they do not have access to land. For young women, access to land is even more difficult, as they experience and suffer from power differences based on social relations of gender and generation.

In the region, agroecological peasants acquired land through the federal government program called land credit. Access to land credit was only possible when peasants' organizations were active in the process of organizing beneficiaries and negotiating with the government. However, the lack of an effective land access policy by the government led the organizations to look for non-governmental access alternatives, such as the Joint Land Conquest in Araponga, as well as land occupations by the Landless Rural Workers' Movement (MST).

Other public policies aimed at peasant agriculture have been structural drivers for changes in the landscape. Among the agroecological peasants analyzed, 40 % had access to structural public policies, such as agroecological technical assistance, institutional (new) markets, and credit. Technical assistance was facilitated by specific calls for proposals to support agroecological Technical Assistance and Rural Extension (ATER) by non-governmental organizations, such as CTA. The governmental calls for university research in interface with extension allowed for the development of the methodology of agroecological exchanges, named “*intercâmbios agroecológicos*”, considered a collective technical assistance approach.

The newly created institutional market, encouraged by public policies such as the National School Feeding Policy and the Food Acquisition Program, was another important structural driver that demonstrated how the economic and the political dimensions are linked between them and how they are also linked to the other dimensions of the agrifood system. For example, the purchase of food from peasant agriculture, with or without differentiated prices for organic food by the government institutional market, not only favors family income, but also encourages diversification on a sustainable basis and thus boosts agroecology. In addition, this new market policy makes high quality food available that otherwise is not always available in local markets.

Government policies across a broad national spectrum, such as environmental legislation and agricultural credit, were the most influential structural drivers of changes in land use, with effects on the landscape. There was an increase in surveillance measures to protect forest areas and greater financial support for coffee cultivation. Increased environmental surveillance has increased environmental protection and forest conservation throughout the Zona da Mata. As a result of these political drivers, between 1986 and 2015, pastures decreased in the central portion of the Zona da Mata from 76 to 58 % of the total area, while there were increases in the area under forest (from 18 to 24 %) and coffee plantations (from 3 to 11 %). The reduction in pastures has allowed an increase in the area protected with forests, but without a reduction in the number of animals. As a result, the supply of food produced with the use of pesticides and genetic-modified organisms (GMO) has increased.

Eucalyptus plantations and urbanized areas also increased over the same period. The area occupied by coffee plantations was positively correlated with the rural credits obtained and earmarked to produce this crop and with the annual coffee exports. The consequence of landscape changes has been an increase in the provision of ecosystem services, cultural services, carbon storage, water flow regulation, soil erosion control, pollination, and habitat quality. Production of peasant units in agroecological transition have been positively influenced, as they are in landscapes where such services have been provided. Although the landscape has changed, the region can still be considered very degraded. The agricultural credit, as PRONAF, has mainly encouraged the use of the Green-Revolution technological package, with an increase in the use of pesticides and synthetic fertilizers. Therefore, there is a lack of credits that really support the agroecological transition.

## 4. Discussion

### 4.1. Dimensions

The 29 social, cultural, environmental, economic, and political drivers identified are interconnected. These socio-ecological dimensions and the relationship between human groups and nature in different contexts, are not easy to disconnect. Some of these drivers refer to basic resources for the agroecological transition, others are fundamental for guiding the meanings and principles that motivate the actions of those involved in the transition process, while others are structural drivers in making this transformation possible. We made a deliberate effort to separately analyze the five dimensions important for the agroecological transition, while at the same time recognizing their interrelationships,

feedbacks and potential synergisms.

Other studies have also reflected on classifications of drivers and evaluating their relative importance. Mier Y Terán et al. (2018) listed eight key drivers, viz., (i) recognition of a crisis that motivates the search for alternatives, (ii) social organization, (iii) constructivist learning processes, (iv) effective agroecological practices, (v) mobilizing discourses, (vi) external allies, (vii) favorable markets, and (viii) favorable policies. Their first key driver, which was mentioned in the Introduction as the recognition of the unsustainable nature in both environmental and socio-economic aspects of the Green Revolution, but all their eight key drivers do overlap with ours.

The classification by Anderson et al. (2019) referred to six critical domains that are also consistent with the classification by Mier Y Terán et al. (2018) and ours. All three classification emphasize the intrinsic and fundamental political nature of agroecology. Different from the two other studies, our long-term study in the region allowed us to deepen the analyses of the drivers, for instance, by specifying the achieved transformations linked to each driver. We will end this section by reflecting on potential synergies between drivers.

#### 4.1.1. Social dimension

The social organization of family and community work is a driver based on relationships of reciprocity (Sabourin, 2010) in the context of ties of kinship, proximity, and affinity (Woortmann, 1994). The roles socially attributed to gender and generation (Woortmann, 1990), especially those attributed to young people, have been transformed within the framework of the agroecological perspective in a dialogical relationship with other national movements, such as feminism and agroecology in the National Agroecology Articulation (ANA) and international movements such as the World March of Women.

The social organization at different scales was crucial to the experience in the studied region (Gomes, 2020; Goris, 2020; Teixeira, 2020; Van den Berg, 2020), where a group of organized civil-society institutions in partnership with a public federal university, formed a network of relationships that converged actions in favor of the agroecological transition, despite facing adversities and challenges. Social organization played a key role in the transition processes and was anchored in the socio-cultural, environmental, and political-economic reality of the region and built locally contextualized solutions that were articulated regionally, nationally, and globally (Teixeira, 2020). In Brazil, the social organizations such as ANA, ABA (Brazilian Association of Agroecology), the Landless Worker's Movement (MST), the Ecovida Network (Rede Ecovida), and the peasant unions and movements promote meetings, national conferences, agroecological caravans, among other actions that strength the agroecological networks, avoid isolation of the agroecological peasants, and promotes synergies and connections. This social organization is different from other countries, where many groups support agroecology, but where their work is undertaken without a bigger picture approach and in isolation of other stakeholders (Schiller et al., 2020).

These networked organizations at state and national level, in a collective action (Chauí, 1982), launched themselves into political arenas to propose and demand public policies and programs of relevance to agroecological transition. At the same time, by launching themselves into the political arena, the organizations updated agendas, informed themselves, and interfered positively at local level through their actions (Chauí, 1982). In this dual movement, the organizations strengthen the joint struggle to have support from the state and understand ways and define strategies for peasant families to access national policies with the content they need (Chauí, 1982). However, from 2018 to 2022 there was no support from the national government for public policies for agroecology and the support for agribusiness was greater than it used to be. This illustrates how changes in the political context can have major impacts on the agroecological transition.

In Brazil, the advocacy work of agroecological organizations and movements, articulated at local, state, and national levels, includes

issues such as commercialization in short supply chains and institutional purchases, with productive inclusion and health security; agrarian reform and territorial rights of indigenous peoples and traditional or local communities; landrace seeds, biodiversity, water and the environment; culture and communication; technical assistance and rural extension; support for production and organization and combating violence against women; education for young people; control and restriction of activities, such as the application of pesticides, which generate negative impacts (ANA), (Available at: <https://agroecologia.org.br>, accessed October 1, 2022). These issues are on the agendas of the Zona da Mata regional organizations.

The political influence of these organizations indicates the power of action and movement in a network that involves public and civil society institutions organized for the agroecological transition. The advocacy work of civil society on legislative and executive powers made it possible to institutionalize agroecological policies. The ways that made such institutionalization possible requires further study, which may reveal other drivers of this transformation. However, the civil-society organizations also have autonomy from the government, which guarantees that they can critically position themselves when necessary, another aspect that needs to be explored in future studies (Lavalle and Szawko, 2015). In addition, networking has enabled useful flows of information for the agroecological transition and the co-creation of knowledge, in a dialogical and horizontal way between different actors, which has proven to be extremely important for the strategies to manage the agroecosystem regionally, nationally and internationally.

The agroecological exchanges and experimentations are essential for co-creation of knowledge. Experimentation means anchoring the agroecological transition on the ground where peasants walk and work, which is important for the realization of the agroecological transition. The co-creation of knowledge gives greater social credibility to agroecological practices and encourages them to be expanded within family and community relationships because of peasant sociability (Woortmann, 1994). In Brazil, the co-creation of agroecological knowledge was and has been based on popular education, which presupposes the horizontalization of knowledge (Zanelli et al., 2015). Popular education, in its different forms, is aligned with agroecology, and provides different possibilities for training young people and adults from the perspective conceived by Freire (1970). In the case of young people, engagement is important for their permanence in the countryside, a challenge that peasants are facing in different parts of the world nowadays (Pollnow et al., 2023), including Zona da Mata. However, since the young people have promoted and generated cultural transformations that broaden the audience for action of local social organizations by bringing new culturally different groups into the movement and thereby broadening agroecology (Goris, 2020).

As pointed out by Goris (2020), the meaning of agroecology in the region has also been filled by the social diversity promoted by young people, who are including and challenging the peasant culture with sexual diversity, and gender and generational roles topics. With this, young people are repositioning their vision in relation to their parents and promoting transitions. However, young people, especially women, continue to suffer discrimination and oppression within their family and outside groups because of sexist prejudices and patriarchy, which puts them in a more challenging situation during the transition (Goris, 2020). As an example of the discrimination young women face, peasant fathers often give a piece of the coffee field to be managed and make profit to their sons, rather than their daughters.

#### 4.1.2. Cultural dimension

Affective work and relationships between humans and non-humans through encounters and social practices are of great importance (Goris, 2020; Van den Berg, 2020). This cultural dimension of the human condition is related to identity (Cunha, 1985) and to the social world vision (Löwy, 1985), based on bonds of peasant sociability (Woortmann, 1994) and collective memory (Halbwachs, 1990).

Therefore, the social world is constructed based on mental categories, perception schemes, and collective representations that are differentiated and go beyond the mode of productive appropriation driven by the utilitarian dynamics of the economy and the social differentiation of individuals (Acselrad et al., 2004). Thus, for social mobilization, the organizations in Zona da Mata connect to a local logic of appropriation of the material world with operations of signification of nature. Thus, the social values activated in the meanings attributed to agroecology by the organizations was in line with the peasants' social worldviews, which include relationships between humans, and between humans and non-humans, and their logic of appropriating the material world. This worked in favor of the agroecological transition. The relationship between this logic and the ancestral matrices present in the Zona da Mata region (Barbosa, 2005; Lamas, 2013; Wilson, 2021) and their religiosities merits future research.

In Brazil, not only indigenous ethnicities (Cardoso de Oliveira, 2006), but also Afro-descendant and other ethnicities are expressed in several peasant features (Monteiro, 2011). The cultural dimension related to ancestry reveals different agricultural logics that materialize in the designs of agricultural systems (Costa Filho, 2008; Monteiro, 2019), which may require different strategies for agroecological transition. In our understanding, different from what Rigolot and Quantin (2022) stated, spirituality is not the major "blind spot" of agroecology, and it does not remain largely based on a material paradigm. We recognize the strong influence of CEBs and peasant worldviews in the development of agroecology in our region, as demonstrated in other research conducted in the region (Botelho et al., 2016; Wilson, 2021). However, in future studies, deepening the understanding of the role of cosmivision and spirituality in the conservation of agrobiodiversity and their relationship with food culture is necessary. Indeed, especially in the challenging context of climate change, cosmivision and spirituality have also been considered in the redesigns of agriculture systems (Rigolot and Quantin, 2022). Likewise, the analysis of ethnic discrimination has gained relevance (Goris, 2020) and could become important topics for future studies.

#### 4.1.3. Environmental dimension

The present research showed the effects of peasant agroecological systems on the provision of mutual benefits of humans to nature and nature to humans (Matuk et al., 2020). These benefits rely on the synergies created among the components of biodiversity. The design of agroecological food systems should strategically use biological diversity and include the combination of annual, perennial, and cover crops, livestock, aquatic animals, and trees (Barrios et al., 2020) that should be managed to promote benefits, including food production, and soil and water quality and quantity.

Society needs to recognize that the provision of such benefits involves supporting the agroecological transition processes of peasant families and their communities through, for example, public policies. Support for agroecology is even more necessary in a climate change scenario, because biodiverse agroecosystems, as proposed by agroecology, are more resilient to the predicted changes (Favero et al., 2014). For example, with the climate change forecast, for the region to continue to produce coffee, agroforestry systems, a biodiverse agroecosystem, will be necessary (Gomes, 2020). The forecast is that by 2050, the increase in the region's average temperature will lead to a reduction of almost 60 % of the area currently suitable for full-sun coffee production (Available at: <https://www.ipcc.ch> accessed on Nov, 02, 2022). However, under agroforestry systems, 75 % of the area will still be suitable for coffee production in 2050 (Gomes, 2020). Agroforestry systems with 50 % shade cover can especially mitigate the impact of climate change at altitudes between 600 and 800 m in the region (Souza et al., 2012; Gomes, 2020). In addition, the presence of trees in coffee systems leads to the presence of a greater number of pollinators and natural enemies (Ferreira, 2008; Rezende et al., 2014; Moreira et al., 2019) and increases nutrient cycling (Duarte et al., 2013), which leads to a reduction or

elimination of the use of external inputs. The increase in forests can also mitigate the impacts of climate change (Teixeira et al., 2020).

In the Zona da Mata, agroforestry systems, mainly with coffee, were implemented in a participatory manner. In a participatory rural appraisal, peasants indicated the weakening of their land as one of the main problems to be tackled (Cardoso et al., 2001). Participatory experimentation with agroforestry systems was proposed to strengthen the land. This experimentation has been systematized (Souza et al., 2012) and agroforestry systems have been widely studied. Agroforestry systems have protected soils and drastically reduced erosion (Franco et al., 2002), increased nutrient cycling (Duarte et al., 2013), conserved and increased water (Carneiro et al., 2009), diversified production (Souza et al., 2012), and increased biological control and pollination (Ferreira, 2008; Rezende et al., 2014; Moreira et al., 2019), among other benefits. Agroforestry home gardens are also recognized as important providers of ecosystem services. The agrobiodiversity found in home gardens, which provides most of the food production for families and animals, is mainly responsible for food security and sovereignty, as well as helping families' finances. Some of the products from the home gardens are marketed, which not only contributes to the financial autonomy of farming families, but also improves the diet of consumers. The home gardens are managed especially by women without the use of synthetic inputs, which guarantees biological, chemical, and physical soil quality and the greater efficiency of the home gardens when compared to coffee plantations (Monteiro, 2019).

Despite the progress made, the challenge is not small, as government policies in regions with economies strongly anchored in commodities, such as coffee in the area, and in the current phase of world capitalism (Chesnais, 1996), do not consider the importance of diverse systems for tackling climate change. This is explicit in the conditions of the National Program for Strengthening Family Farming (Pronaf), which offers agricultural credit to peasants historically conditioned to the use of synthetic inputs (fertilizers and pesticides) in monocultures (de Tolentino, 2016). Agriculture in the Zona da Mata continues to be largely based on Green-Revolution packages, with a recent increase in the use of genetically modified seeds, especially corn, which has concomitantly increased the use of herbicides. In Brazil in general, and in the region in particular, the research, education and extension institutions continue to predominantly favor production systems that are highly dependent on industrialized synthetic inputs.

#### 4.1.4. Economic dimension

One of the policies indicated as possible support for agroecological systems is payment for ecosystem services. However, payment for ecosystem services has been criticized due to the possibility of reducing non-human nature to an entity or resource that can be measured, quantified, and commodified so that it can be marketed for the benefit of powerful actors (Van den Berg, 2020). There is also the possibility of recognition, with even non-material rewards, for those who manage their systems in co-production with nature (Van der Ploeg, 2008).

Market-related issues, such as lack of consumer demand and strong vision on economic growth and exportation are considered strong barriers for the transition to more sustainable farming systems (Verburg et al., 2022). The transition in Zona da Mata shows that it is possible to overcome those barriers through the development of alternative and local markets for a diversified production. The experience of the region shows that the agroecological transition is multidimensional and for it to take place it is necessary to diversify production, redesign the agricultural system and marketing strategies, raise critical awareness and social organization with networking and institutional guarantees to ensure resilience in the face of internal and external challenges. Agroecological transition, as is happening in Zona da Mata, needs to be a response of place (Santos, 2002) to the hegemonic global order with unsustainable agrifood systems. This response must act not only in the development of adaptive techniques to improve agricultural practices on an ecological basis, but also in the economic-political and socio-cultural dimensions of

transforming reality, with a focus on the peasantry. In the search for sustainable agrifood systems, agroecology can play a key role in terms of form and content, based on its understanding as a science, movement, and practice (Wezel et al., 2009; Associação Brasileira de Agroecologia, 2015; Favero and Pacheco, 2013).

#### 4.1.5. Political dimension

Our results reaffirm the importance of public policies and programs in making the agroecological transition possible, for instance, through investments to land access, production, technical assistance, and agroecological rural extension and commercialization. From a European context, Molina Navarro (2015) also stated that without public policies and institutional framework it is impossible to spread agroecology and promote sustainable agrifood systems.

For agroecological transition, access to land is essential, as it is the productive material base and the bearer of meanings attributed by cosmovisions. Moreover, land access allows for greater autonomy, which is important for agroecological transition. Land is understood in a broad sense, a territorial fraction where the other natural resources vital to life (soil, water, and biodiversity) are territorialized (Raffestin, 1983), which is fundamental to the social and cultural reproduction of the peasantry (Shanin, 1979). In Brazil, this is a challenge, as it is currently one of the countries with the highest land concentration in the world, with a Gini index of 0.87 (Instituto Brasileiro de Geografia e Estatística – IBGE, 2017). The Brazilian land structure is a socio-historical product that has consistently neglected the peasantry (Silva, 2008; Oliveira, 2005), but at the same time has given rise to historical struggles, including in Zona da Mata, since the colonial period (Lamas, 2013). The Zona da Mata reflects the land structure of Brazil. On one hand, there is a concentration of land by a few big farmers and, on the other hand, small pieces of land owned by many peasants, who in a strong communal effort managed to buy and keep the land under their control. Although the land credit policy has given many peasants in the region access to land, it has not solved the problem of land concentration. Other strategies for accessing land have taken place in the region. In Araponga, the so-called Joint Land Conquest allowed access to land in the municipality. At least 174 peasant families, representing 2/3 of those who own less than 10 ha, acquired land via the Joint Land Conquest (Campos, 2014). Joint access to land in Araponga revealed greater autonomy in decision-making regarding biodiversity management (Campos, 2014; Van den Berg, 2020).

Despite all these initiatives, for agroecology to expand in the region, a plan for agrarian reform that allows peasants access to land with autonomy is necessary. At the same time, understanding the territoriality of these groups in the region and the various flows between ethnically close groups can reveal other important dynamics and drivers for agroecological transition. Elsewhere, territorial dynamics have revealed gene flow logics or other ways of collectively conserving germplasm adapted to local soil and climate conditions (Monteiro and Dayrell, 2014).

The political dimension has also been marked by state action, which is expressed in the transformations of the landscape through laws (such as the protection of the Atlantic Forest) for land-use planning and the economic policy of agricultural credit. The agricultural credit for production is mostly accessed by large landowners in Brazil (Instituto Brasileiro de Geografia e Estatística – IBGE, 2017) and particularly supports the use of the technological package of the Green-Revolution (de Tolentino, 2016). The credit most accessed by peasant families is named Pronaf. In cases such as Pronaf, credits increase the use of external inputs, including agrochemicals, and decrease autonomy of the farmers (Nicholls and Altieri, 2018). However, peasant families have organized themselves in the country and have also secured access to a small amount of Pronaf for agroecological transition, with specific funding lines for women and young people, which is albeit difficult to access given the conditions required (land ownership, for example).

Recently, there have been investments in public policies for

agroecological Technical Assistance and Rural Extension (ATER), in which the co-creation of knowledge has been prioritized. However, the status-quo continues to be top-down technical assistance and rural extension, strongly based on the knowledge of the technician. Agroecology is highly knowledge-intensive, based on techniques developed in cooperation with peasants' knowledge and experimentation and with strong connection to food sovereignty. These practices are best adopted if they are not imposed top-down by technicians, but shared from peasant to peasant (de Schutter, 2014).

In Brazil, the newly created institutional markets boosted peasant agriculture and agroecology. Institutional markets refer to the purchase by the state of food from peasants for consumption in schools and social welfare institutions, such as hospitals (Porto, 2016). The institutional markets make it possible to sell the production of agrobiodiversity at minimum prices based on market value plus 30 % (if certified as organic), which generates monetary income for families based on the sale of several products, not only on one commodity, such as coffee. One of these programs is the National School Feeding Program (PNAE). By law, at least 30 % of the food procured for schools must be bought from family farmers. Nicholls and Altieri (2018) considered PNAE one of the best examples of public policy to support agroecology.

The experience of the Zona da Mata reaffirms the role of state action through public policies to broaden the scope of the agroecological transition (Molina et al., 2021), which can be thought of and contextualized in different realities or places. However, single policies do not suffice. Rather, combinations of complementary policies are crucial for the transformation of agri-food regimes (Mier Y Terán et al., 2018; Nicholls and Altieri, 2018). Challenging the agrifood regime with its productivist paradigm is extremely difficult (Vermunt et al., 2022). Public policies depend on the power relations and barriers created by the agri-food regimes within each country (Sabourin et al., 2018; Gaitán-Cremaschi et al., 2020). The political-economic power behind the hegemonic agri-food systems controls credits, seeds, technologies, information, national and international research agendas (Nicholls and Altieri, 2018), and, in some cases, the mind of people. In Brazil, public policies needed for the transition to agroecologically-based peasant production are hindered by the ultraconservative political pact that defines Brazilian agricultural policy that privileges monoculture to export and multinational companies to the detriment of peasants and sustainability (Corcioli et al., 2022). In Nicaragua, Schiller et al. (2020a, 2020b) noted a weak implementation of agroecological practices even though agroecology became the national policy in the country. The authors identified the co-optation of an agroecology discourse by actors associated with the dominant, conventional regime as a main cause of this weak national policy implementation. Therefore, stimulating niche innovation, such as in Zona da Mata, is necessary, but not sufficient. Intervention in current regime dynamics is necessary, which can be done through appropriated public policies but also other actions, which are beyond the scope of the paper.

#### 4.2. External and internal conditions

For the agroecological transition process, it is important to understand that there are internal or external forces. According to Gaitán-Cremaschi et al. (2020), external and internal conditions that limit the re-design of agroecosystems and the ecological intensification can also be understood as the limitation of agroecological transition. The external forces do not depend directly on the peasants and their organizations, such as the power of the agrifood empires (Van der Ploeg, 2008), which require an internationally articulated political struggle to be transformed. Similar to our case, the limited external conditions identified by Gaitán-Cremaschi et al. (2020) are the little economic and institutional support in comparison to the dominant systems; little representation at the policy level; and no support from dominant value chains such as the traditional marketing channel that favors standardized products and economies of scale. Schiller et al. (2020) also

identified the lack of consumer awareness of the social or health-based benefits of consuming agroecologically as an external condition that limits the transition towards agroecology. Although in Zona da Mata there are groups of consumers that support the farmers, such as Rede Raízes da Mata, it is far from the ideal scenario in which more consumers procure agroecological food. Nationally, a big campaign called “Agrotóxico Mata” (Pesticides Kill, in Portuguese) was launched against pesticides, and helped increase awareness, but it is still not enough.

Among the internal forces, Schiller et al. (2020) identified lack of communication between successful agroecological experiences as limiting the transition. In Zona da Mata, the lack of communication has been overcome through promotion by the social organization of knowledge exchange meetings, some with similarities to the “campesino a campesino” model, as suggested by Nicholls and Altieri (2018). “Campesino a campesino” (or peasant to peasant) is the methodology used in Central America to internally promote agroecology, with great success (Mier Y Terán Giménez Cacho et al., 2018).

However, in the transition process, there is also the dialectic of internal and external. For example, an agroecological social movement can, for example, win public policy for the transition (external driver) through its collective action (internal driver). Furthermore, the classification into external and internal conditions is not rigid, because depending on the situation the external condition becomes internal and vice versa; in many cases the driver is both internal and external, acting in conjunction. A group of peasants can, for example, join the struggle for land and win land for their family to produce agroecologically. In other words, the situation can change, leading to new arrangements of the internal and external conditions necessary for agroecological transition, which influences the drivers. Understanding the external and internal forces of power taking place in the territory is important to find the good strategies to act. There are forces that hinder the transition, which should be combated, and others that enhance the agroecological transition, which should be reinforced. These are the binomial enhance – hinder or announcement - denunciation (Freire, 1997) that are very often used by the agroecological movement in Brazil. If external or internal, the strategies to act can be different.

#### 4.3. Synergies and interdependence between drivers

Barrios et al. (2020) indicated synergies as one of the 10 elements of agroecology. They highlighted the need to promote synergies among the components of the managed ecosystems to re-design agricultural and food systems but also indicated the importance of partnerships, cooperation, and responsible governance, involving different actors at multiple scales, including multi-stakeholder partnerships, to promote agroecology. Here we emphasize the synergies among the drivers and their importance to the agroecological transition (Fig. 3). The experience in the Zona da Mata shows that drivers have different capacities to push forward agroecological transition. The existence of a previous social organization in the region, with a religious and political basis was important in driving the agroecological transition. But this was possible due to the presence of an organization (CTA-ZM) geared towards promoting agroecology in the region. CTA-ZM, which worked in partnership with peasant organizations and the university (UFV) in favor of the transition. Thus, in the Zona da Mata agroecological transition process, science, movement and practice (Wezel et al., 2009; Associação Brasileira de Agroecologia, 2015) took place. However, this would not have been possible in isolation. Connection, as emphasized by Vermunt et al. (2022) is essential to the agroecological transition.

Political engagement in national networks, such as the ANA, to guarantee public policies clearly focused on agroecology, was also an essential driver for promoting the agroecological transition in the region. Public policies on technical assistance, credit and agroecological marketing have expanded the transition in the Zona da Mata. Therefore, the combined action of these drivers, such as the existence of a social movement focused on transition and public policies in favor of

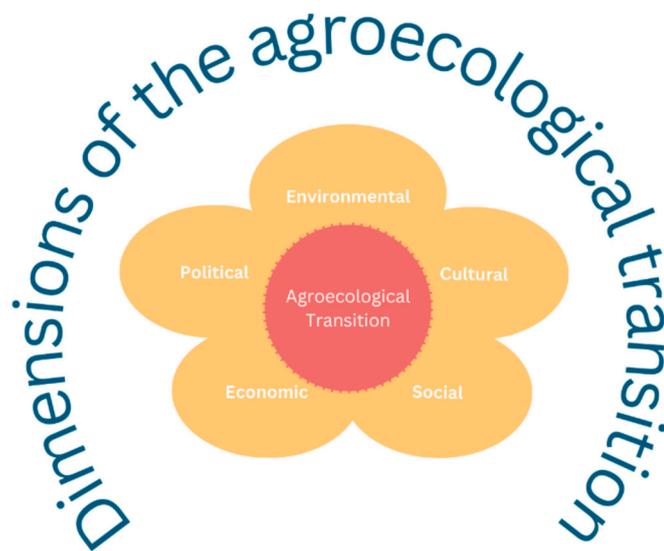


Fig. 3. Interconnection between different dimensions of the agroecological transition.

agroecology, is a powerful stimulus to transition and guarantees greater effectiveness in the implementation of public policies.

Another key factor in the transition was the mobilization of cultural values, cosmovisions and peasant identity to engage families in the transition, with gender and generational relations playing a key role. The identity was reinforced by the promotion of the participatory construction of knowledge, with a formation of a critical awareness in relation to the Green Revolution and the promotion of nature-based technical solutions that guarantee family autonomy. These drivers generated a combined dynamic favorable to the agroecological transition, as it enabled the translation of agroecological principles into practices, identified by Nicholls and Altieri (2018). The support of public policy (especially the institutional markets) was also important in the transition.

As Barrios et al. (2020) pointed out, to promote synergies within food systems, and best manage trade-offs, agroecological transitions should emphasize the importance of partnerships, cooperation and responsible governance, involving different actors at multiple scales, including multi-stakeholder partnerships. Thus, in Brazil, social organizations (ABA, ANA, MST, CTA, Rede Ecovida, etc.) promote networks at various scales and at the same time promote various synergies and connections among drivers.

However, rather than synergy, as pointed by Barrios et al. (2020) there were, in most situations, interdependence among drivers. For instance, the political-institutional environment creates favorable conditions for the transition and the organizations, consequently, finding the means to make agroecology a reality, in a dual cause and effect relationship that feeds back on itself and makes it possible to re-design agricultural food systems.

## 5. Conclusions

We identified 29 drivers related to the agroecological transition in the Zona da Mata region of Minas Gerais, Brazil, based on the concrete experiences of peasant families. These drivers allowed us to identify and understand the elements that promote or hinder agroecological transitions. Peasant families are central to the process of agroecological transition and to the transformation of the agrifood system. It is essential to guarantee access to land, strengthen social organization, consider cultural aspects of the group, promote the management of locally adapted biodiversity and increase income while reducing production costs. Furthermore, without adequate public policies, the agroecological

transition can take place, but it does so slowly. Nevertheless, agroecological public policies must not negatively affect the creativity and autonomy of peasants.

Agroecological transitions are based on transformations in the socio-ecological environment and the relationship between human groups and nature in different contexts. By changing the context, the internal and external conditions necessary for the agroecological transition can be altered, which influence the agency of the drivers. This takes place at different scales, from local to international, and between the different social segments involved. Drivers also have different roles in the transformation process (basic, foundational and structural).

The convergent actions of peasants, technicians, researchers, social movements, civil society and public organizations are necessary to articulate different drivers in favor of agroecological transitions. The co-creation of knowledge, local experimentation and institutional strengthening, through collective action for the creation and implementation of public policies, are aspects of the transition in which social organization anchored in socio-cultural, ecological, and political-economic reality plays a key role, building local solutions that are articulated regionally, nationally and worldwide. These actions take place on the land and its territorialized resources, water and biodiversity, considering the cultural meanings and practices that underpin the synergies in favor of agroecological transitions. The culture-nature relationship under a logic that is not merely exploitative or for economic profit exclusively, is a key element of agroecology's resilience in time and space, expressed through practices, knowledges and movements to guarantee socio-ecological reconstruction in favor of sustainable food systems.

Proper public policies and institutional frameworks are equally crucial to spread agroecology and promote sustainable agrifood systems. As evidenced in this Brazilian case, when there was a drastic reduction in public policies for agroecology, during a non-democratic government, the transition was negatively affected. However, public policies must be in interaction with a strong political movement based on bottom-up practices. This interaction and feedback between public policies and social movements, supported by peasants, scientists, and other actors is crucial for the agroecological transition. With too much focus on local initiatives by social movements, there is a risk that the agroecological transition remains a niche phenomenon; with too much focus on the policies and institutions, there is a risk that the agroecological discourse is hijacked by the productivist paradigm that maintains the current regimes. Theories on agroecological transitions should therefore further articulate feedbacks and potential synergisms between those top-down, institutional, and bottom-up, socio-cultural, processes, and recognize the inherent political nature of both.

The agroecological transition in this specific region (Zona da Mata, Minas Gerais) took place over a period of more than 40 years and is still taking place, indicating the long-term nature of the transition process. Theories of agroecological transitions should therefore become more explicit about temporal dimensions in order to develop sustainable agrifood systems. Despite the strength of the agroecological transition process, the predominant form of agriculture in many parts of the world, including the region where the present research took place, still favors monocultures, the use of external inputs that are harmful to humans and non-humans, and affronts peasant culture. This is because the hegemonic agricultural system, based on industrial latifundia, is anchored in public policies that have historically favored it, indicating the urgency for public policies that support agroecology. A better understanding of the resilience of the productivist paradigm and the way it can neutralize or invert the agroecological transition is therefore another research priority.

Finally, we identified that there are several terminologies being used to refer to the transition in agroecology. There is a need for papers that synthesize the state of the art about what has been produced, especially in Latin America, where agroecology has been promoted for a long time. However, we don't understand agroecology as stages to be followed in a

linear process. The agroecological transition is a continuous process and a complex movement of understanding and practical appropriation of ecological and social principles that promote the development of sustainable agri-food systems built on the interaction between actors, nature and places through networking.

### CRedit authorship contribution statement

**Fernanda Testa Monteiro:** Writing – original draft, Methodology, Investigation, Conceptualization. **Alexandria Jeanne Wilson:** Writing – review & editing, Investigation. **Heitor Mancini Teixeira:** Writing – review & editing, Investigation, Conceptualization. **Lucas Carvalho Gomes:** Writing – review & editing, Investigation. **Raphael Fernandes Bragança:** Writing – review & editing, Supervision, Resources, Project administration. **Maria Izabel Vieira Botelho:** Writing – review & editing. **Ivonete Lopes:** Writing – review & editing. **Felipe N.B. Simas:** Writing – review & editing. **Thomas W. Kuyper:** Writing – review & editing, Resources, Project administration, Investigation, Conceptualization. **Irene Maria Cardoso:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

### Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Fernanda Testa Monteiro reports financial support was provided by Wageningen University. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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### Data availability

No data was used for the research described in the article.

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