

Socio-technical transition in the palm oil sector: analysis from a multilevel perspective in Colombia's municipality of Tibú

Transición sociotécnica en el sector de la palma aceitera: análisis desde una perspectiva multinivel en el municipio Colombiano de Tibú

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Abstract: Changes in the interactions between agents involved in the value chain of the palm oil sector in the municipality of Tibú (Colombia) over the period 1985-2020 have resulted in a reduction in the indices of poverty, social inequality, and unemployment for the inhabitants of the region, which can be explained by a process of socio-technical transition. The main objective of this study is to analyze the factors that determined the success of this process from a multilevel perspective. Exploratory research was developed based on a case study analysis using semi-structured interviews of commercial and non-commercial agents in the sector and information collected from secondary sources. The results show that changes in the legal and regulatory framework established by the government, landscape transformation, and the transition from small farmers to medium entrepreneurs of the farms in the region were important factors revolutionizing the system and are encouraging the emergence of new alternative practices in the palm oil sector.

Keywords: socio-technical transition, social innovation, multi-level perspective, transition management, technology policy, technological change.

Resumen: Los cambios en las formas de interactuar entre los diferentes agentes involucrados en la cadena de valor del sector de la palma de aceite en el municipio de Tibú (Colombia) durante el periodo 1985-2020 han dado como resultado una reducción en los índices de pobreza, desigualdad social y desempleo para los habitantes de la región, lo cual se explica por un proceso de transición sociotécnica. El objetivo principal de este estudio es analizar desde una perspectiva multinivel los factores que determinaron el éxito de este proceso. Para lograr este propósito, se desarrolló una investigación exploratoria basada en el análisis de un estudio de caso mediante entrevistas semiestructuradas aplicadas a agentes comerciales y no comerciales del sector, y la recopilación de información de fuentes secundarias. Los resultados muestran que los cambios en el marco jurídico y normativo establecidos por el gobierno, la transformación del paisaje y la transición de pequeños propietarios a medianos empresarios agrícolas en la región, fueron factores importantes para revolucionar el régimen y fomentar la aparición de nuevas prácticas alternativas en el sector del aceite de palma.

Palabras clave: transición sociotécnica, innovación social, perspectiva multinivel, gestión de la transición, política tecnológica, cambio tecnológico.

1. Introduction

Recent globalization processes in which the economy has been immersed have been accompanied by great competitive market pressures and the need for firms to reduce their production costs with strategies such as incorporating new technologies and providing greater support for research and development processes (Coron & Gilbert, 2020). Although technological change is generally considered to evolve together with technology, it is also a human creation that is part of a social process (Volti, 1989) made up of systems that have a socio-technical composition (Walker et al., 2008). This composition groups agents (people and companies), institutions (social and technical norms, regulations, and good practice standards), materials, and knowledge.



With all this, it is possible to develop socio-technical transition processes based on social links that allow the fulfillment of social needs such as nutrition, transportation, communication, and more. Technology plays a decisive role in satisfying these needs (Geels, 2004). Although these processes can be carried out in all production sectors, in the particular case of the agricultural sector, it is possible that the transition towards more efficient agriculture is not only driven by technology but also by social innovation. This is because radical changes in beliefs and values of social actors are necessary (Darnhofer, 2014) within a non-linear process in which technological, social, and economic subsystems interact and evolve to create patterns of change (Geels & Kemp, 2007).

A socio-technical transition process can be configured from two perspectives. One is made up of standards and instruments that address environmental, social, and economic problems associated with the production processes of goods and services. These must be implemented by commercial agents (Swyngedouw, 2005). They are evidenced through permanent audits as mechanisms to regulate relations between organizations (Busch, 2011). The other perspective is through research conducted from various scientific disciplines which explores two approaches of the evolution of new technologies and innovations to respond to the needs of society (Markard et al., 2015). The first of these approaches relates to national, regional, sectoral, and technological innovation systems (Cooke et al., 1998; Edquist, 1997; Malerba & Nelson, 2009). The second emphasizes a socio-technical context in which technologies and innovations gradually develop and diffuse to align, reconfigure, transform, and even replace existing systems (Darnhofer, 2014; Schot & Steinmueller, 2018). As a result, changes in socio-technical systems occur from the so-called multilevel perspective (Kemp et al., 2007) as socio-technical transitions are conceptualized from evolutionary economics, sociology of technology, and neo-institutional theory (Geels, 2012).

Based on the literature on socio-technical transitions, this article aims to answer the question: Can palm oil cultivation in a specific region of Colombia be studied from the perspective of socio-technical transitions as a case study? When analyzing agricultural production in the world, oil palm is a product that has acquired great worldwide importance in the last fifty years. Its production has increased from 2 to 70 million tons over the period 1970-2020 and exports increased 400% between 1988 and 2013 (Statista, 2022). Within the consumption of oils and fats, palm oil reached a 30% share of global consumption in 2016 (Foo & Aziz, 2019), mainly explained by a growing product demand in countries such as China, India, and Brazil (Montoya et al., 2020). Indonesia, Malaysia, and Thailand are the main producers with 87.9% of total world production, followed by Latin America with 6.5% (Oil World, 2020). Colombia is the fourth largest palm oil producer worldwide and the largest palm oil producer in the Americas (Corley & Tinker, 2015). Currently, production in Colombia is geographically distributed into four major regions: eastern, central, northern and western. The traditional model of oil palm processing in these regions is characterized by a concentration of land and productive assets among minority groups with high financial independence. They obtain benefits not only as growers, but also from the development of other activities related to oil palm processing such as large scale commercialization of agricultural inputs and their sale at high prices to small and medium growers in the sector. However, the municipality of Tibú, in Colombia's northern region, exhibits a divergence from this palm oil extraction system. In recent years, a radical change has been observed in the productive structure and social organization of producers in the framework of a socio-technical transition process (Perdomo, 2015). It has allowed them to move from an exclusive role as oil palm growers to a broader one where they act as entrepreneurs who generate added value for the region (Torres, 2017). This has become evident in terms of employment generation, growth in productive infrastructure, and an improvement in the region's human capital formation processes.

Literature reviews find that research related to socio-technical transition processes is limited since most of it is concentrated on developed countries, in specific sectors such as industry, energy, health, and mobility (Nesari et al., 2022), and doesn't take into account socioeconomic aspects of the agents involved. There is an absence of studies that analyze in detail the processes of socio-technical transition for low-income countries in specific sectors such as agriculture. Therefore, this research attempts to fill this gap.

The document is structured as follows: Section 2 presents the theoretical foundation, specifically oriented towards the impacts that globalization has generated on economies of scale and price reduction, which could be explained by technological transitions. Section 3 provides the research methods used. Section 4 presents the discussion and results of the coevolution process from the analysis of existing documentation as well as results obtained from applying semi-structured interviews on the context of the Global South. Finally, the conclusion section summarizes the main research findings.

2. Theoretical Foundation

The dynamics of trade and globalization processes have significantly impacted generating economies of scale and reducing prices of goods. These impacts can be explained by firms permanently incorporating technological innovations (Ashford & Hall, 2019). The diffusion and use of new technologies within firms is not a simple and instantaneous process that depends exclusively on technology, but also on economic, social, and institutional characteristics of the local and global economic environment (Reinstaller, 2008). The socio-technical perspective studies these interactions between technical and social elements, and is based on institutional theory and evolutionary economics (Manon & Bermúdez, 2016).

One of the main elements to be taken into account when analyzing socio-technological transition processes is to establish the factors that determine the transition from a pre-established technology to a new one. New forms of socio-technological transition must incorporate sustainability components and a more intelligent use of resources to counteract the problems associated with climate change and social inequities in sectors such as energy, housing, transportation, agriculture, and health (Smith et al., 2010). In some cases, achieving a socio-technical transition is difficult because dominant technologies resist competing alternative technologies, generating so-called technological lock-ins (David, 1985). Although eliminating these blockages is fundamental for the achievement of a socio-technical transition, it is necessary to identify and understand the nature of the tipping points at which one moves from one dominant technological regime to another as this can contribute to establishing the role played by different public and private actors (Zeppini et al., 2014). A tipping point defines the way in which a technological system makes the transition from one state to another (Lenton, 2013). One of the main tipping points found in the literature traditionally refers to the number of agents that decide to adopt one technology or another (Ecosystems Services for Poverty Alleviation, 1999). In order to better understand the mechanisms that generate technological blockages, models based on complexity theory have been designed that contribute to the process of identifying inflection points when there is a transition from one dominant technological regime to another. These models show that the sources of technological lock-in are variable, as are the mechanisms that lead to technological transitions.

In the specialized literature there are a variety of models to establish the threshold as a way of explaining the socio-technical transition. Models such as hyperselection (Bruckner et al., 1996), coordination games (Arthur, 1989), informational cascades (Bikhchandani et al., 1992), and social influence (Granovetter, 1978) use the threshold concept from the traditional perspective.

Contrastingly, the percolation model (Solomon et al., 2000) establishes the threshold in terms of a critical price below which a socio-technical transition is reached. Finally, coevolutionary models (Kauffman & Johnsen, 1991) set the threshold in terms of comparisons between existing differences in skills, abilities, competencies, and qualifications between a new and an old technology.

Similarly, some models are aimed at understanding how socio-technical transitions are produced by linking expectations, motivations, and other factors that affect the behavior of firms (Acs, 2006; Bolton & Thompson, 2013). In turn, these models make it possible to establish what changes are needed not only in terms of technologies, but also of cultural practices, public policies, business models, markets, and infrastructures, which in this context can be conceptualized as socio-technical systems (Elzen et al., 2004).

Not all models of socio-technical transition emphasize the importance of radical innovations, nor do they take into account the participation of multiple societal groups. These groups, including firms, universities, research centers, consumers, society, and others, engage in different activities within the context of societal beliefs, norms, rules and institutions. However, these collective efforts of these groups make these transitions possible. In contrast, Geels' (2002b) so-called multilevel perspective, by its nature, allows for understanding complex transitions involving multiple actors and activities, as well as cultural, technological and infrastructural elements (Medina-Molina et al., 2022). This perspective provides more information on which factors are relevant and how they interact (Geels & Schot, 2007). These transitions occur through interaction processes within and between three analytical socio-technical levels: socio-technical landscape, socio-technical regime and small networks.

The multilevel perspective proposes three levels. First is the landscape, made up of an exogenous structure and a group of heterogeneous factors such as macroeconomic patterns, climate change, cultural values, and environmental problems, where agents interact through technological trajectories (Rip & Kemp, 1998). Second is the socio-technical regime, defined as the dominant practices within which tangible and intangible transactions are carried out (Baxter & Sommerville, 2011; Rip & Kemp, 1998), regulated by a deep structure of beliefs, norms, routines, political paradigms, and social expectations (Geels, 2011). These in turn involve socio-cultural factors that allow the development of business-type activities (Méndez-Picazo et al., 2021). The socio-technical regime is characterized by being stable and integrated by sub-regimes such as user, market, political, and scientific trends. These sub-regimes have their own dynamics, but are complementary and co-evolve simultaneously (Geels, 2004) in such a way that they provide information on the stability of existing technological development and the emergence of trajectories (Geels, 2002b). Third, there is a space where radical innovations emerge which are designed and developed by small networks of external or marginal actors (Schot & Geels, 2007) requiring spaces (incubators) to be protected from the dominant market. This protection is usually subsidized by the state, sector authorities, or investors (Kemp et al., 1998) who have the potential to exert sufficient pressure to change or replace entrenched regimes (Hoogma et al., 2005). Understanding and analyzing the interactions that arise between the three levels is essential to understanding the dynamics of transitions to sustainable socio-technical regimes (Späth & Rohracher, 2012).

The multilevel perspective is then formed by the analysis of the interaction between socio-technical landscape, socio-technical regime, and small network technological levels, forming a nested hierarchy based on the theoretical analysis of complex and technical systems, innovation studies, and long wave theory. The aim is to study and explain change in socio-technical systems (Geels, 2002b; Rip & Kemp, 1998). The heuristic initially formulated by (Rip & Kemp, 1998) shows that small networks represent the generation and development of radical innovations that arise as a consequence of disarrangements with the existing regime, such as inadequate infrastructures, or incompatible regulations.

According to (Geels, 2002a, 2002b), they materialize as a result of the multiple interactions that allow them to link and align. In this context, the present research is based on the multilevel perspective which gives rise to a radical transformation, explained by Schot & Geels (2007) as a profound change in the structure of the regime, and whose effect produces dynamic equilibriums, providing space to nurture innovation and in turn allowing adaptation to a gradually changing selection environment.

3. Methodology

The mechanisms and transactions through which technological transition processes are generated in the palm oil sector are complex (Gruber, 2020). To develop this work and efficiently capture the complexity of the phenomenon, exploratory research implemented a qualitative methodology based on case study analysis. In addition to adopting an integrative perspective, case study analyses are universally associated with strategies of questioning the “how” and “why”, allowing for deeper levels of understanding of phenomena in real world environments, and they explain reality with a greater degree of objectivity (Barnham, 2015). This research developed the analysis through a stepwise process (Figure 1) based on the criteria established by Yin (2013) who defines a case study as empirical research that studies a contemporary phenomenon in-depth within its real context, especially when the phenomenon may be context dependent.

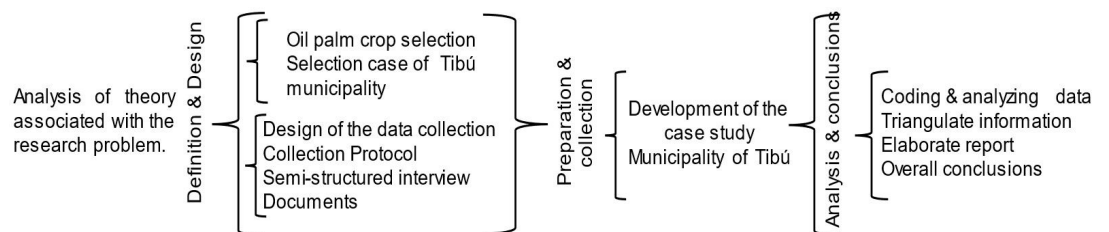


Figure 1. Analysis process - single case.

Source: Own elaboration based on the criteria established by Yin (2013).

Information was collected in 2018 through two mechanisms. The first was by conducting semi-structured interviews with primary sources in the region making it possible for both the interviewee and the interviewer to interact freely, enriching the quality of the information and its interpretation (Díaz-Bravo et al., 2013). Six commercial agents were interviewed in the sector with managerial responsibilities: three middle managers in palm oil extraction plants and five palm producers in the region. The second mechanism was by collecting secondary information elaborated by public entities as well as national and international organizations with expertise in the subject. Twenty-two documents were selected that dealt with the municipality's specific situation. The documents covered the following topics: biodiversity (1), illicit crops (5), public policies (2), alternative development (2), right to land (1), displacement (2), exclusion (1), and negotiation (8). These texts were analyzed under the criteria developed by Scott (1990) to evaluate their quality, credibility, and authenticity. They were used to understand the circumstances that gave rise to the change in the socio-technical systems between their different levels.

In order to analyze the socio-technical transition from the above-mentioned sources, a triangulation process was carried out as shown in Figure 2. This process is a qualitative strategy that, according to Denzin (2017), allows comprehensive understanding of the changes in the socio-technical transition process by using multiple data sources, and, in parallel, to ensure the saturation, objectivity, and validity of the research (Guion et al., 2011).

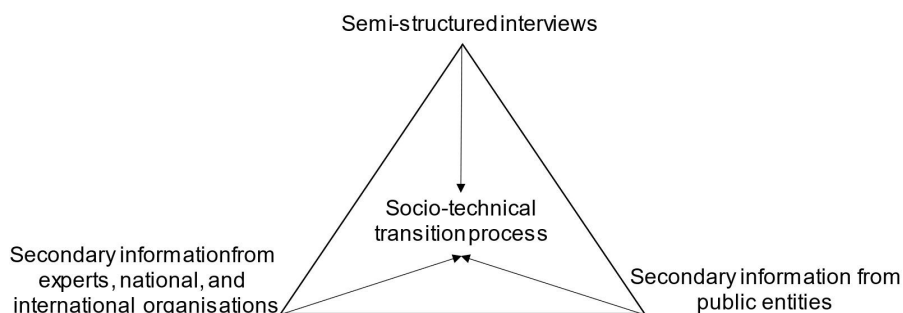


Figure 2. Information triangulation process.

Source: Own elaboration

Semi-structured interviews were conducted with prior, expressed, and informed consent of the participants, who agreed to provide the information under the condition of anonymity, with an approximate duration of 60 minutes. The interviews were divided into four sections: general information (name of the extracting company or name of the farm), landscape (external factors that exert pressure on the regime such as violence, unemployment, education, and economic development of the region), regime (supply networks, market, policies, and production infrastructure), and other socio-economic features (hectares planted, family stability, quality of life, level of education). The participants sampled for interviews were selected by non-probabilistic sampling, a method that uses non-random selection criteria, including the knowledge of the individuals by an expert (Navidi, 2006).

From the data collected, replicable and valid inferences were made based on the technique of qualitative content analysis, a method that allows for the systematic description of the meaning of the information (Mayring, 2000) in order to determine patterns, codifying and categorizing them into relevant elements in the recorded communication. These are dynamics developed from the multilevel perspective that responds to those of technological transition developed by Geels (2002a, 2002b). This process yielded 11 categories: biodiversity, illicit crops, distrust, alternative development, land rights, displacement, education, exclusion, infrastructure, negotiation, and state presence. These categories were processed through the systematic method of text condensation by NVivo software (QSR International Pty Ltd., 2021), which organizes, categorizes, and labels large amounts of data in an efficient way. Text condensation was carried out in four stages. First, transcriptions of the interview recordings obtained the data in text format. Then, the information was read and reviewed to identify patterns and recurring themes, which made it possible to identify terms associated with the research topic. Next, the data was grouped into thematic categories and subcategories to enhance coherence and contribute to a better understanding of the relationships between the themes. Finally, the information was analyzed and synthesized to understand the mechanisms and transactions that gave rise to the technological transition of the sector in the region.

4. Results and discussion

The findings presented in this article are part of the development of the doctoral thesis entitled "Analysis of the relationship between innovation and governance in the sustainability of agroindustries: the case of oil palm in Colombia." The study analyzed the four zones of the national territory that specialize in production and extraction of the oilseed (Southwest, East, Central, North). This article presents results from the northern zone, specifically from the municipality of Tibú.

Due to the complexity of the mechanisms and transactions that generate social innovation in the municipality of Tibú, the study explains the process of coevolution through the interactions of agents at three analytical levels: socio-technical landscape, socio-technical regime, and small networks. This provides an understanding of the changes obtained in the technological system involving simultaneous processes in multiple dimensions and levels. These changes affect various branches of the regional economy and give rise to new industries in the region, such as organic fertilizers, spare parts, and transport companies.

4.1 Socio-technical landscape

The municipality of Tibú is situated in the Catatumbo region of northeastern Colombia (Figure 3), on the border with the Bolivarian Republic of Venezuela. Part of this region is classified as a forest reserve zone, with ample biodiversity and water resources, and is an area of high productive potential for the nation (Programa de las Naciones Unidas para el Desarrollo, 2014).



Figure 3. Geographical location of the municipality of Tibú

Historically, this region has had a scarce institutional presence of the state, leading to a deteriorating standard of living of its inhabitants and the productive potential of the region (Instituto de Ciencia Política Hernán Echavarría, 2016). The increase in the area dedicated to illicit crops and levels of deforestation (Castiblanco et al., 2015; Dávalos et al., 2011) has led to an increase in criminal activities, generating an unfavorable social balance which uproots and excludes a large part of the population (Fundación Ideas para la Paz, 2017). As a result, the population is left in a situation of greater vulnerability (Gutiérrez et al., 2018). However, the economic importance of palm oil at the global level and state intervention have been an incentive for the inhabitants of the area to increase their production, exerting parallel pressure on the regime to be able to do so effectively and more efficiently.

4.2 Socio-technical regime

The process of socio-technical transition in the municipality of Tibú is motivated by a series of structural and conjunctural causes that can be considered barriers within the established regime for it to become effective, as stated by Hertog et al. (2022).

Socioeconomic characteristics of the population

A high percentage of the inhabitants of the municipality of Tibú are farmers who do not have the right to exercise their full citizenship. This is evident in their limited access to health services, education, and infrastructure. It is accompanied by a high degree of concentration of income and land ownership (Oficina para la Coordinación de Asuntos Humanitarios, 2007; Restrepo, 2013) in a small group of growers who have a privileged position in the value chain of the industrial transformation process and the commercialization of palm oil. Thus, there was a sense of exclusion of the smallholders who felt that despite playing an important strategic role in the region's economy, they were not taken into account in key decisions affecting them, leading to permanent social instability (Rubio et al., 2004).

For example, conflicts over land and territory arose from the 17th century onwards with the formation of *latifundios* (Centro Nacional de Memoria, 2016), large landed estates that often relied on partial servitude of laborers, unfairly disadvantaging the most vulnerable members of the population in favor of the landed gentry. Another aggravating factor was that the Colombian state issued Law 80 of 1931 which granted a contract for the exploitation of national lands located in the Department of Norte de Santander. It granted the Gulf Oil Corporation the following:

They are the subject matter of the present contract and on the other national lands bordering the area of the pipeline, its branches and terminals, of the rights and easements that it deems necessary or convenient for the fulfilled execution of the contract in all that refers to the construction works of said pipeline with its accessory services. (Colombia, 1931, p. 4).

Political exclusion

The existence of a political class that remains unaware of the reality of the territory, permeated by illegal groups in some cases, results in scarce opportunities for the inhabitants of the municipality of Tibú to actively and effectively participate in political and economic spaces. The limited participation of the inhabitants in the construction of the development model of the municipality and the region has accentuated corruption processes in the execution of efficient public policies in a transparent manner (Chavarro & Otálora, 2020). This is narrated by some of its protagonists:

What we need here is a real presence of the state to try to build society. Here there is no law enforcement presence. The health services are terrible. Education is poor. There is no access to roads. There is no law here. There is no authority (Interview with palm grower #7, 15 November 2018).

Lack of trust in government agencies

The main sentiment expressed by farmers is the repeated violation of commitments made by regional and national governments to improve the quality of life.

But basically, what was said during the visit of President Duque was that he committed himself to return to the issue of the CONPES, which is the road to La Mata. That this would be a huge solution. The transport costs would of course be reduced. But he did not deliver (Interview with palm grower #1, November 12, 2018).

In addition, social leaders in the region face two problems that threaten their integrity: stigmatization by government authorities and an attempt by illegal groups to appropriate social protests. This ends up intensifying the conflict in the region and obstructs the construction of social and economic alternatives for the area (Centro Nacional de Memoria Histórica, 2015).

Bad policies from development models

Initially, the development models proposed by the national government for the region were oriented towards reducing illicit crops. By 1998, Tibú produced 70% of the total narcotics in the region (Colombia, 2016). This resulted in the implementation of a program to eradicate of illicit crops through aerial chemical spraying (Walsh et al., 2008), which led to peasant protests demanding the creation of a development plan accompanied by economic initiatives to substitute illicit crops.

Low bargaining power

Most farmers in the region operated under a marketing regime characterized by little room for maneuver in negotiating both the price of the product and the time to receive the money from sales. In this sense, they obtained low prices and slow access to monetary resources, resulting in two negative impacts. First, expected profit levels were reduced. Second, there was a default on the financial obligations contracted by the farmers, ultimately leading to an increase in the payment of financial penalties and in their production costs.

Production infrastructure with limitations

The palm growers did not have an extraction plant. Therefore, to process the palm fruit, it was necessary to transport it by land from Tibú to the nearest plant located in another municipality in the region (Codazzi), a journey that could take between 12 and 14 hours depending on the state of the road. This, in addition to increasing logistical costs, affected product quality because the fruit became overripe during the journey, causing acidity problems and, consequently, a loss of quality in the finished product that had a knock on effect on prices (Interview with palm grower #1, November 12, 2018).

4.3 Small networks

Given the characteristics of the established regime and the landscape, government intervention was important for the emergence of small networks (Figure 4) in which alternative social practices and configurations develop. From this, new ideas, business models, and ways of doing things began to emerge among small farmers. In addition to generating social and economic impacts in the region, farmers in some ways began to become part of the regime or even a substitute for it.

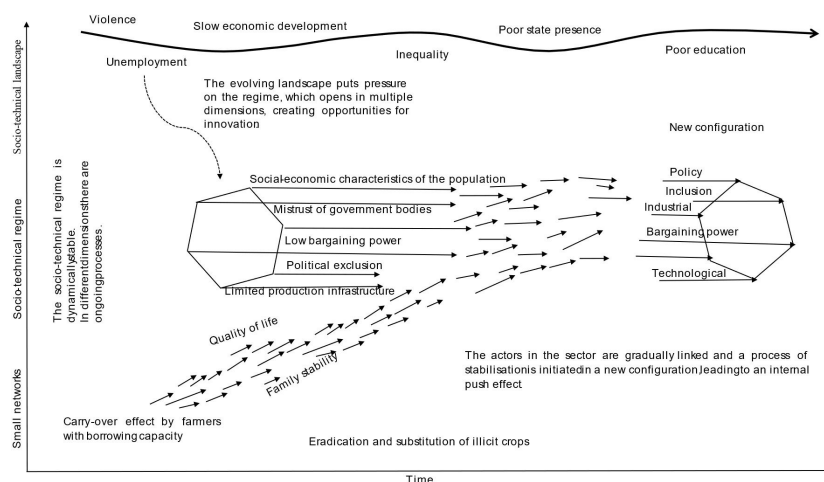


Figure 4. The multilevel perspective of transitions.
Source: Adapted from (Geels, 2004).

The initiative to stimulate oil palm production by farmers arose from various government strategies aimed at eradicating illicit crops in the region. Thus, in 1995, the first government proposal was a social policy instrument called the National Alternative Development Plan (PLANTE), implemented in 1998. Its main objective was the voluntary manual eradication of illicit crops, accompanied by productive projects that promoted developing medium and long-term agricultural and agroforestry projects favoring oil palm (Vargas, 2010). The Colombian government, through the Ministry of Agriculture, was the main agent involved in the socio-technical transition process by formulating two strategies. The first implemented a model of productive alliances in establishing a union between large producing *haciendas* and important groups of associated small producers (Rodríguez et al., 2010), with an integrating partner that supplied fertilizers, seeds, technical assistance, and acted as a buyer of the palm fruit (Oleoflores, 2022). This made it easier for small and medium-sized oil palm producers to not only access markets, but also technical information, financing, infrastructure, and technological innovation (Neven, 2015). A second stage of the project to promote oil palm cultivation began around 2004, funded by resources from the United States Agency for International Development (USAID) and the Banco Agrario de Colombia, a state-owned financial institution whose main objective is to offer banking services to the rural sector. At this stage, a new operating model was established in which small producers could sign pledge contracts to comply jointly and severally with the financial credits obtained from the bank or an integrating partner and to sell exclusively the palm fruit to the extracting company for a period of 25 years in what can be called a captive governance model (Gereffi et al., 2005).

This legal and regulatory government framework with the fundamental objective to substitute illicit crops with oil palm, led to the first steps in developing radical innovations. In this context, small farmers began to develop political and negotiation skills based on the increase in production. These skills allowed them to position favorable small networks for their interests within the framework of a socio-technical transition. Initially, more than 1,200 small and medium-sized producers were grouped into three palm nuclei, creating close to 7,000 direct and indirect jobs, which led to the consolidation of the municipality and the region as one of the most important palm groves in the country (Fedepalma, 2018). In addition and complementary to the planting and production of oil palm, there was an increase in other transitory and permanent crops such as cocoa and coffee, generating new avenues for trade and social, environmental, and economic development (Gutiérrez, 2016).

From a technical perspective, a key aspect within the socio-technical transition process for the generation of added value by the growers was the construction of an oil extraction plant. This fundamental innovation within the socio-technical transition benefited not only the growers of Tibú but also other farmers from other municipalities in the region. However, the process was not simple, and its execution was slow due to various blocking mechanisms that arose from different social interests and some cognitive limitations that prevented the perception of the advantages of constructing the plant. Plant construction gradually gained momentum internally with the union of 96 small palm growers, each with 8 hectares of cultivated land, and 10 medium-sized growers with similar interests and greater financial capacity. These medium-sized growers ended up playing an important role as guarantors of the process, thus solving not only the extraction problem in the area, but also improving the quality of life of the inhabitants of the region. In addition, the growers experienced greater support in terms of access to productive innovations and new technologies from national institutions such as the Federación Nacional de cultivadores de Palma (Fedepalma) and international institutions such as the Roundtable on Sustainable Palm Oil (RSPO), which have a solid structure in terms of innovation.

The general pattern that generates radical innovations in the region follows trajectories of small network accumulation (Geels, 2002a). The first activities took place within the context of the illicit crop boom stimulating the inhabitants of the region to generate resources for their own survival. Governmental, political, and military actions opened new paths for change processes to take place within the region to substitute illicit crops. This transition was and continues to be complex, as it implies cultural changes, experimentation with new crops, knowledge transfer, new ways of life, and commercialization processes. The incursion stage of palm oil crops was associated with the need for the creation of extraction companies, transportation systems, agricultural products, and skilled labor. These needs generated great expectations among inhabitants and the need to implement a socio-technical transition of the new small networks and opportunities for the region. This eventually generated pressure on the regime, giving rise to small new networks and opportunities that led to innovations and changes in the regime.

In general, the socio-technical transition process occurred gradually and arose because of a need for change of variables such as the growing violence in the municipality and the region, lack of employment, and multiple social and economic deficiencies. Although the change that was generated may seem like a quick revolution, it was the result of a series of modifications that occurred gradually over time. It is important to highlight that the government proposal for crop substitution was presented in 1998. Crop substitution began in 2001, and in 2015 the palm oil extraction plant was inaugurated (Summerton, 2021). It is evident that within the economic, social, and environmental panorama of the region there have been a series of important transformations, entering into a dynamic of changes that have been widely disseminated and, that in some ways, have managed to transform the existing system. Although the transition from illicit crops to oil palm crops is a fundamental element in the socio-technical transition process, this process faced multiple risks due to the emergence of new violence hotspots in the area. Although an agreement was signed between the Colombian State and the Revolutionary Armed Forces of Colombia (FARC) in 2016 in which a solution was defined for the problems associated with illicit crops with the aim of transforming the countryside, the dynamics of the incoming government at that time for fulfilling the agreement was not as expected. Many of the regions continued in a situation of poverty and state neglect, which led to a new emergence of illicit crops in many regions by other armed groups who see the municipality of Tibú and its surroundings as a feasible objective, once again becoming a production zone for this type of crop.

Faced with the problems of social exclusion, scarce opportunities to decide on their political future, non-compliance with agreements by governmental entities, and conflicts over land, it is necessary that the government and farmers in the area jointly define policies that seek a balance in the environmental, social, and economic aspects in order to contribute to accordance with the needs of the region. In the specific case of the municipality of Tibú, the multilevel perspective can be replicated in other regions, given its potential to generate a significant positive impact for the nation and the capacity to generate formal and stable employment.

One of the most important challenges for the region and the nation will be to develop processes aimed at the eradication of illegal crops based on new and better opportunities for the communities living in the area. Efforts should be made for these from social innovation initiatives to generate legitimate and legal welfare and development.

The main limitation of this research was access to information due to the problems of public order in the region. No similar studies have been found in Colombia that allow comparisons to be made, and from these comparisons, try to find better ways to implement these processes. Future research should focus its efforts on increasing the transformative potential of social innovations and include commercial and non-commercial agents to formulate policies aimed at responding to the challenge of finding a balance in social, environmental, and economic dimensions.

5. Conclusions

This article was developed based on the guidelines of a multilevel perspective to understand the dynamics between agents, institutions, and society with the palm oil sector in the municipality of Tibú and thus establish the causes that have led to a change in business model.

An important pattern in the advance of innovations from the level of small networks originates in the interrelation, alignment, and positive feedback between multiple technologies to generate momentum. The co-evolutionary process in the region has not been linear. It is the result of multiple interactions of the agents that make up the three analytical levels: small networks (locus of radical innovations), socio-technical regimes (locus of established practices and associated norms), and the landscape.

As a consequence of the pressure of the landscape on the regime (dominant practices), new opportunities opened up for the networks formed by small farmers. These farmers were mature enough to take advantage of these newly opened opportunities and were able to change the configuration of the dominant practices in the municipality.

It was found that the process of incubation of small networks framed within the socio-technical transition originated in the opportunities that were opened on the one hand by the Colombian State through the crop substitution policy, and on the other hand by the Agrarian Bank by generating credit facilities. At the same time, the small farmers received collaboration from the Ministry of Agriculture and other organizations responsible for supporting the palm growers in terms of welfare, progress, and productivity. This situation contributed to the success of this activity.

In general, changes in the legal and regulatory framework established by the government, the landscape transformation, and the transition from small farmers to medium entrepreneurs of the farms in the region were important factors to revolutionize the regime and encourage the emergence of new alternative practices in the palm oil sector.

This research presents a contextual analysis of a highly controversial worldwide sector using the theoretical framework of socio-technical transitions. This process has not been applied before. Therefore, this research generates a theoretical contribution that analyzes the implications of the application of this framework in a specific case. It delivers a methodological contribution by showing how an analysis could be carried out in other agricultural and non-agricultural sectors. It also makes a practical contribution by providing tools to strengthen alternative practices in the agri-food system.

One of the limitations of the study is that the multilevel approach is normally used to analyze complete systems, and not particular cases. This situation generates limitations when characterizing a specific phenomenon.

This work opens the way for further research to determine the extent to which these initiatives are triggering long-term transition pathways in agricultural contexts. Further research would also assess the real contribution of these initiatives in resolving social conflicts in regional environments of the Global South characterized by low levels of education, scarce state presence, infrastructure deficiencies and high production costs.

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