# Soybean Supply Chain Management and Sustainability: A Systematic Literature Review

Fu Jia, PhD (First author)
Chair Professor of Supply Chain Management
The York Management School
University of York
Heslington, York YO10 5DD
Tel: +44 (0)1904 324855
Email: fu.jia@exeter.ac.uk

Sujie Peng
The York Management School
University of York
Heslington, York YO10 5DD
Email: sp1539@york.ac.uk

Jonathan Green
Stockholm Environment Institute
Department of Environment and Geography
Third Floor, Environment Building
University of York, York
YO10 5NG, UK
Email: jonathan.green@york.ac.uk

Lenny Koh
The University of Sheffield
Management School
Conduit Road
Sheffield S10 1FL
Email: S.C.L.Koh@sheffield.ac.uk
Tel: +44 (0) 114 222 3395

Xiaowei Chen (correspondence author)
Zhejiang Gongshang University,
No.18 Xuezheng St.
Hangzhou 310018, China P.R.
Email: chenxiaowei@zjgsu.edu.cn
Tel: +86 (0) 13958080203

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***Declaration of Interest Statement**

Declaration of conflict of interest statement

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Author names: Fu Jia; Sujie Peng; Jonathan Green; Lenny Koh; Xiaowei Chen

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## Abstract

As a globally consumed agricultural product, soybeans have long been one of the most important commodities in the current international market. In this regard, the governance of the global soybean supply chain has become one of the central themes in both industry and academia. However, existing scholarly works focusing on sustainability issues and mechanisms for better governance in the soybean chain are rare. Moreover, the relationship among soybean supply chain governance mechanisms remains unclear. In this study, we conducted a systematic review of the existing literature to identify key themes or topics and to develop a conceptual framework to guide future research. Based on our inclusion criteria and by considering the Scopus database, we identified and reviewed 55 articles published between 2000 and 2019. In our analysis, four themes were identified in soybean supply chain management: drivers (e.g., land-use conflict), global value chain governance (e.g., REDD+), consequences (e.g., reduced $CO_2$ emissions) and potential barriers (e.g., low market demand). Finally, a conceptual model was proposed that elaborates the linkage of the themes, and a research agenda was proposed to direct studies in the future.

**Keywords:** Soybean; Sustainability; Supply Chain Management; Value Chain Governance

## 1. Introduction

Soybeans are a widely consumed agricultural commodity around the world in many forms, such as the whole soybean, soy oil and soy meal markets (Fearnside, 2001). However, only 6% of the world's total soy production is used in the form of whole beans, while the remaining 94% is crushed (Oliveira and Schneider, 2016). Whole soybeans may be processed for industrial usage (e.g., biofuel and edible oils) or crushed to produce food products (e.g., soy milk, animal feed, and soy sauce) (WWF, 2014). In addition, compared with the other crops, soybean has the potential for greater resource efficiency. Taking land-use efficiency, for instance, a soy yield of 3000 kg per hectare can be used to produce 343 kg of cattle meat, 600 kg of pork or 1200 kg of poultry (Garrett and Rausch, 2016). Otherwise, without soy meal, cattle production can only produce one head and 250 kg of cattle meat on average on one hectare of land (Walker et al., 2013).

Agricultural production has long attracted concerns related to environmental sustainability (Silva et al., 2010). The soybean supply chain requires a much longer transportation distance to meet global demand (He et al., 2019). The long-distance transportation route finally leads to environmental and social challenges, such as Green House Gas (GHG) emissions (He et al., 2019) and food insecurity for local people (Federación Agraria, 2007). This contrasts with the short food supply chain (SFSC), where a shorter distance within the chain improves sustainability by developing the local economy, reducing diesel fuel consumption and building closer relationships between stakeholders (Schmid et al., 2014; Sellitto et al., 2018). Engagement with stakeholders to tackle environmental and social issues is easier in an SFSC as the relationship is closer (i.e., stakeholders are more willing to pay for sustainable products in SFSC) (Hinrichs, 2003; Schäufele and Hamm, 2017). Hence, in this context, a more facilitated mechanism is required for better governance in the soybean chain.

In the existing literature, many research findings have associated soy production with ecological problems, such as excessive water usage (Ercin, 2012) and deforestation (Ferreira et al., 2013). Additionally, social impact concerns, including the loss of livelihoods and increased rural conflicts (Espíndola and Cunha, 2015; McKay, 2018), have drawn the attention of scholars and stakeholders. Again, the challenges caused by unsustainable soy production may vary among the various producing countries. For instance, the GHG emissions concerns in Brazil mainly come from deforestation and land-use conflict rather than from fossil fuel use (Borzoni, 2011). In this sense, numerous problems have arisen: what are the main challenges of unsustainable soy expansion in soy-producing countries, and what are the management implications? To the best of our knowledge, these issues have yet to be addressed holistically in the extant literature.

On the other hand, concerns regarding the governance of the soy global value chain (GVC) have arisen. In this context, the governance of value chains refers to the collaboration between actors and their activities as well as the relative powers among stakeholders within the chain (Humphrey and Schmitz, 2002). Many initiatives have been implemented by actors in the public and private sectors to improve governance practices in soy value chains. The governance of the soybean value chain is the management by actors related to soy cultivation, which may raise questions about the mechanisms that are effective for governing the actors in the soybean supply chain and the drivers and potential barriers behind these mechanisms.

In many tropical countries, both governmental and non-governmental organisations have implemented numerous initiatives to enhance sustainability in the agricultural sector (Newton et al., 2013). Examples include the Roundtable on Responsible Soy (RTRS) and the Brazilian Soja Plus (Heron, 2018). Such initiatives seek to change production practices throughout the chain by engaging multiple stakeholders to tackle environmental or social issues (e.g., deforestation) (Meijer, 2015). Additionally, Heron et al. (2018) discussed both public and private certificate schemes in global soy value chains to address environmental or social concerns. Still, the weaknesses in the sustainability initiatives (e.g., low coverage rate) (RTRS, 2017; Virah-Sawmy et al., 2019) have yet to be thoroughly discussed. Thus, a study focusing on a holistic understanding of the mechanisms of soybean chain governance is important but uncommon. Additionally, the relationships among these mechanisms remain unclear.

Some previous studies have reviewed the extant literature on sustainable and agricultural value chain governance. Under the context of value chain governance, Bush et al. (2015) reviewed the mechanisms used in value chain governance and classified them into three types: governance in chains, governance of chains and governance through chains. Lambin et al. (2003), in a similar vein, reviewed private and public deforestation initiatives under a sustainable supply chain management context. They suggested that public and private initiatives need to reinforce each other to create collective efforts for complex ecosystems. Again, considering the complexity of the soybean chain, Heron et al. (2018) and Waldman and Kerr (2014) reviewed the current certification schemes and argued that customer-focused certification schemes were required to adopt practices and tackle environmental pollution. Nonetheless, the relationship between governance mechanisms has not received any significant attention. Collectively, prior works only presented how soybean production is governed, while a systematic review of this topic is missing. Hence, the aim of this study was to analyse the existing literature to present an overview as well as the strengths and weaknesses of the existing works. The following research questions are proposed:

RQ1: What are the drivers and barriers to sustainable soy production and their relationships?

RQ2: What are the value chain governance mechanisms available for the soybean chain?

RQ3: What are the consequences of the implementation of these mechanisms?

The remainder of this article is structured in five sections: first, the systematic review process adopted in this work with descriptive analysis is described in the next section of the research methodology; second, in the thematic analysis section, we present the key themes identified; third, we propose a conceptual framework based on the identified themes; fourth, we show and discuss the implications of the study; fifth, in the conclusions, we summarise the paper and suggest potential areas for further research.

## 2. Research methodology

In this study, a systematic literature review (SLR) was adopted. The systematic literature review methodology is presented in this section.

### 2.1 Reviewing process

We adopted Scopus, the largest database of peer-reviewed literature with holistic coverage of academic articles, as the database for searching the literature (Elsevier.com, 2019). To define the scope of the study, we identified three clusters of keywords (Figure 1). We searched the articles by using the following portfolio: soy and sustainability-related keywords; soy and supply chain-related keywords; and soy, sustainability and supply chain-related keywords to ensure that the terms used in this study better identified articles (i.e., the scope could not be too broad to search the literature). Specifically, we used the “advanced search” on Scopus to search for the following keywords: First, we used soy OR soybean OR “soy meal” OR “soybean meal” OR “soy conflict” OR “soy moratorium” OR “soy frontier” OR “soy complex” OR “sustainable soy sector” OR “soy meat” as terms to search for articles related to soybeans. Second, following Jia et al. (2018), we adopted “corporate social responsibility” OR CSR OR “triple bottom line” OR TBL OR sustainab* to search the literature related to sustainability. Finally, the supply chain-related keywords were "supply chain" OR "value chain" OR procurement OR purchas* (Jia et al., 2018). In this process, we chose “Article” as the document type, “English” as the language of the articles, and “Peer Reviewed Journal” as the article type for searching.

Initially, the search result yielded 795 relevant articles in the database. We then used the following criteria to select articles for inclusion: articles focusing on supply chain management (SCM), certifications, and public regulatory standards for soybean production. Of these, the articles that focused on SCM but not on soy production were excluded. We also excluded papers related to soybean cultivation technologies (e.g., no-till cultivation). After reviewing the title and abstract when searching for the articles, we found 168 potential articles for review. Then, adopting the same criteria, we reviewed the full text and finally identified 55 articles to include in the study. The final article search was conducted in December 2019.

Although these articles may provide new perspectives on more sustainable soybean production, limited insights regarding sustainable production mechanisms in operations management were highlighted in these studies.

**Insert Figure 1 about Here**

In the following sections, the descriptive analysis and thematic analysis are presented to evaluate the literature according to the publication information and key themes.

## 2.1 Descriptive analysis

The 55 papers identified in this study were published between 2000 and 2019. The distribution of the papers by year is illustrated in Figure 2. The first publication identified was published in 2000. We noticed that gaps existed between 2002 and 2008. In addition, 10 works were published in 2018, followed by 7 articles in 2019. Of the 55 articles reviewed, 37 were published between 2014 and 2019. For the distribution of papers in journals, 7 papers were published in the Journal of Cleaner Production, which contributed the most papers, followed by 5 articles in The Journal of Peasant Studies (Table 1).

**Insert Figure 2 about Here**

**Insert Table 1 about Here**

As shown in Figure 3, among the reviewed articles, the majority (34) were case studies, followed by modelling (15), secondary data analyses (2), experiments (2), surveys (1) and literature reviews (1) (Figure 3).

**Insert Figure 3 about Here**

## 3. Thematic findings

The soy supply chain is a complex network that creates significant economic profits in many countries, but it requires a large number of supporting services (e.g., infrastructure and processing) (Garrett et al., 2013). In Brazil, for instance, the tax rate on soy-related products is fairly low, and soybean, soy oil or oil exports enjoy a zero-tax rate (Garrett et al., 2013). Such preferential policies enacted by governmental institutions have become a trigger of growth in the production of soy. In this regard, the "side effects" of such initiatives have raised sustainability concerns. Thus, in this paper, our focus is on sustainable soy supply chain management. In line with this focus, in the next section, we adopt Elkington's (1998) triple bottom line (TBL) approach to identify the challenges or drivers of unsustainable soy production as the first thematic category. Subsequently, we discuss the mechanisms for tackling these challenges, which include public and private initiatives. Additionally, the consequences of and potential barriers to the implementation of the initiatives are presented. Following the thematic findings, in section 4, a conceptual framework was developed to establish the relationships among the identified themes.

### 3.1 Drivers

In general, soybean farming systems can be classified into three types: genetically modified (GM), non-genetically modified (non-GM) and organic soybean. In the case of the soybean supply chain, economic, environmental and social issues exist in all farming systems (Kamali et al., 2017). Hence, discussions of these issues are presented in this section.

### 3.1.1 Economic challenges

Once again, the soybean supply chain is a complex network and requires many supporting services (e.g., infrastructure and processing), which creates a large amount of economic value (Garrett et al., 2013). For example, in Brazil, the soy supply chain contributed 0.7% of the national GDP in 2007; 45% of this was from soy production (Garrett et al., 2013). Azadi and Ho (2010) discussed the economic performance of soybean cultivation, arguing that the introduction of GM soy could increase the productivity of the soybean sector, while food security and other issues need to be considered.

Additionally, several studies, such as Reis and Leal (2015) and Silva and Almeida (2013), have developed models to optimise the operational costs in soybean supply chains. Other economic issues include transportation, inventory and logistic costs (Silva and Almeida, 2013). Apart from these issues, the economic value or profitability depends not only on value creation but also on cost reduction. Azadi and Ho (2010) mentioned indicators of economic performance in the soy sector (e.g., yield production), while Reis and Leal (2015), Silva and Almeida (2013) and Garrett et al. (2013) further discussed techniques for cost optimisation, such as techniques or practices adopted for cheaper production. The adoption of GM technology, for example, leads to higher production and therefore results in higher yields and reductions in operating costs. Additionally, compared with other seeds, GM seeds are available at lower prices, which also reduces operating costs (Delvenne et al., 2013; Filomeno, 2013; Pellegrini, 2013).

However, the economic advantages of GM soybean cultivation raise several questions. First, profitability is highly dependent upon the price of the international soybean markets. Second, profitability is impacted by export taxes, and soybean producers may have to reduce prices to improve their competitive advantage in the international soybean market. Third, future yields may decrease because production practices do not follow the recommended crop sequences. Overall, all these studies have addressed how soy cultivation contributes to economic value. The abovementioned articles are illustrated in Table 2.

**Insert Table 2 about Here**

### 3.1.2 Environmental challenges

In addition to profitability, soy production raises ecological concerns (Garrett et al., 2013). In our reviewed papers, a considerable number of studies analysed the ecological effects of soybean cultivation.

Soybean cultivation has rapidly expanded in the past few decades. The area under soy cultivation in Argentina alone, for example, increased from 6.9 million hectares (Mha) in the 1990s to 19.7 Mha in 2012 (Goldsmith et al., 2004; Mathews and Goldsztein, 2009). Approximately 90% of global soy production is in Brazil and Argentina (Mathews and Goldsztein, 2009). The cultivation of soybeans leads to the loss of natural resources. These include soil erosion and the impact of agricultural chemicals on biodiversity and the environment. For soy production, the environmental effects have been investigated by a considerable number of studies, such as studies about land planning (Garrett et al., 2013), greenhouse gas (GHG) emissions (Newton et al., 2013; Reijinders and Huijbregts, 2008), water consumption (Ercin et al., 2011; Taherzadeh and Caro, 2019), deforestation (Cohn and O'Rourke, 2011; Fearnside, 2001), and land-use conflict (Garrett et al., 2013; Garrett and Lambin, 2013; Garrett and Naylor, 2013; Tomei et al., 2010; Zak et al., 2008). To produce the same amount of product, soybeans require a larger amount of land than rapeseeds (Mattsson et al., 2000; Garrett and Rausch, 2016; Brown et al. 2014). Tomei et al. (2010) and Zak et al. (2008) found that the cultivation of crops (e.g., soybean) caused land-use conflicts (e.g., deforestation caused by soy expansion).

Soy expansion has long been a threat to the ecological system (Silva et al., 2010), especially deforestation (Ferreira et al., 2013). Taking the most common concerns into account, implications regarding land consumption (Weinhold et al., 2013) and deforestation need to be addressed (Ferreira et al., 2013; Gollnow and Lakes, 2014). In the Amazon, for instance, deforestation is caused by large-scale soy cultivation (Arima et al., 2011; Macedo et al., 2012; Morton et al., 2006). The industrial scale of soybean production in South America has led to large areas of deforestation (Cohn and O'Rourke, 2011; Fearnside, 2001) and GHG emissions from long-distance transportation routes (He et al., 2019).

In addition, deleterious effects on the natural environment caused by soybean production were substantially affected by the technologies used in soy cultivation. For example, in GM soybean production, for instance, the use of endosulfan 8 contributes to the pollution of groundwater (Gonzalez et al., 2010). The introduction of pesticides (e.g., glyphosate) for GM soybean cultivation also impacts soil quality (Astoviza et al., 2016; Burachik, 2010; Urcola et al., 2015).

In addition, a certain number of indirect impacts on the ecological system have been found by scholars. Deforestation, for instance, can ultimately lead to the loss of carbon, e.g., large-scale usage of mechanical tillage instead of using no-till practices (i.e., a technique to grow crops without disturbing the soil through tillage), cover crops and maximising harvest residues reduce the carbon stock of the soil and, ultimately, leads to more carbon dioxide emissions (Reijnders and Huijbregts, 2008) and climate change (Fearnside et al., 2013). The loss of carbon not only leads to climate change but also impacts water and soil resources. Macedo et al. (2012) and Neill and Coe (2013) found that the deforestation caused by soy cultivation influences the level of water flow, the sediment, and the temperature. Moreover, GHG emissions caused by deforestation also increase the carbon stored in the soil (Lal et al., 2007). Different from those of developed countries, Brazilian GHG emissions (e.g., 58% of carbon dioxide emissions in 2005) mainly come from deforestation and land-use conflict rather than fossil fuel use (Borzoni, 2011).

Ercin et al. (2012) indicated that soy products, such as soymilk and soy burgers, consume a considerable amount of water, which requires better practices in water stewardship. Specifically, this study examined the water footprint (WF) of soybean production in different countries in the forms of blue water (i.e., the amount of rainfall that enters lakes, rivers and groundwater), green water (i.e., the amount of rainfall that is either intercepted by vegetation or enters the soil and is taken up by plants and evapotranspired back into the atmosphere) and grey water (i.e., the consumption of water used to absorb pollutants based on current water quality standards). Overall, 93% of the WF for 1 litre of soy milk is green water, while the WF to produce a 150 g soy burger includes approximately 100 g (69%) of green water and 40 g (27%) of grey water. In these estimations, it can be seen that the production of soy burgers consumes more water to address pollution.

Ercin et al. (2012) also suggested that excessive water usage in soy cultivation leaves soil with a reduced capacity to absorb water and, ultimately, leads to flooding in some areas. From an international trade perspective, Taherzadeh and Caro (2019) found that approximately one-third of the water and land consumption of soybean production was driven by international trade, of which 70% was used for animal feed, one-fourth (24%) was used in food products and only 2% was lost in the distribution of soybean (i.e., the transportation of soy products). This indicates that in international trade, land-use conflict and water consumption are driven by soy production to meet the demand for animal feed. These studies showed that the challenges existing in soybean cultivation are complex and interlinked and sometimes conflict with one another.

The deleterious effects of soy cultivation on natural environments vary in different national contexts. In Brazil, according to Delgado (2012), Oliveira (2016) and Sauer and Leite (2012), such ecological effects include the deforestation of the Cerrado and Amazon biomes and widespread pollution caused by pesticides and herbicides. Additionally, in China, the effects can be degradation of water and soil, greenhouse gas emissions and biodiversity losses (Schneider, 2014; Yan et al., 2016; Liu et al., 2019). To better illustrate these impacts, the environmental challenges are summarised in Table 3.

**Insert Table 3 about Here**

### 3.1.3 Social challenges

Compared with the economic and environmental aspects of sustainability, the social impacts have received less attention. In this section, discussions regarding the social challenges from soy production are presented.

In some soy-producing countries, such as Paraguay, farmers are more likely to depend on agriculture for income (Elgert, 2016). Although the agricultural sector contributes significantly to job creation in Paraguay due to the high rural population, large-scale soy production offers a limited number of employment opportunities, as it requires more skilful managers and machine operators (Masi and Ruiz Diaz, 2017). Growth in the production of soy can often be seen among a small number of producers. In Bolivia, more than 80% of the soybean processing and storage markets are owned by foreign capital, which means that the soybean market is more likely to be controlled by a small number of large-scale producers (McKay, 2018). In Brazil, soybeans cultivation occupies 30 Mha of land (Espíndola and Cunha, 2015). In 2006, approximately three-quarters of the privately owned land was occupied by 0.8 million medium- and large-scale farmers (Medina et al., 2016). Approximately 75% of Brazilian farm householders make less than the minimum wage, while family farmers face the most severe financial difficulties (i.e., over 80% of family farmers have an insufficient amount of land and only 20% have sufficient access to a market) (Medina et al., 2015).

As a crop with relatively little direct consumption, increasing soy production raises important questions about food poverty and food security (Garrett et al., 2013). Reis (2012) found that due to increases in soy production, approximately 90% of food-insufficient families in Brazil run out of food before their incomes are received, which leads to the purchase of cheap foods for children. Similarly, new positions created in the soy sector often go to immigrants rather than to locals, as these positions require particular skills (Zoomers, 2010; Fearnside, 2008; Sawyer, 2008).

This issue, especially in rural areas, not only leads to poverty but also causes social conflict between local people and migrants (Garrett et al., 2013). With mechanisation in Argentina, for instance, much of the demand for labour has been replaced by the use of sophisticated machines, while access to the job market for local low-skilled farmers is limited (Phélianas and Choumert, 2017). With fewer jobs available, lower-skilled labourers are likely to be replaced by more skilled immigrants (Phélianas and Choumert, 2017). To summarise, these social issues are illustrated in Table 4.

**Insert Table 4 about Here**

### 3.1.4 Linkages among economic, environmental and social challenges

In our reviewed works, we found that both economic and environmental drivers could result in social risks.

First, large-scale soy expansion driven by economic profits is associated with environmental challenges. In many studies (Arima et al. 2011, Ferreira et al., 2013; Gollnow and Lakes, 2014), deforestation has been linked with large-scale soy expansion. Deforestation caused by soy expansion can lead to the loss of carbon (Reijnders and Huijbregts, 2008), impact the level of water flow (Macedo et al. 2012; Neill and Coe, 2013) and contribute to climate change (Fearnside et al., 2013).

Second, numerous social concerns have been raised as a result of the pursuit of profit due to the utilisation of large areas of land for soy cultivation. In Argentina, for instance, approximately 60,000 small farmers left the agricultural sector between 1992 and 2002, as government policy favoured larger producers (Tomei and Upham, 2011). As a result, approximately 60% of the soy products were produced by no more than 5% of farmers (Corregido, 2008). Additionally, criticism over “land-grabbing” driven by economic profitability has caused another social conflict in which land has been controlled by foreigners rather than local investors (Garrett et al., 2016). Like a doubled-edged sword, “land-grabbing” can be both positive and negative in some circumstances.

On the one hand, it allows farmers to settle in urban areas or seek new employment opportunities. On the other hand, it might lead to financial losses when they pay more for new land or cannot find new employment opportunities (Baletti, 2014; Zoomers, 2010). In this sense, farmers may suffer more financial difficulties. In Argentina, soy expansion led to the concentration of land ownership; the concentration process resulted in a decrease in the number of smallholder farmers and expansion by producers who sought to enlarge their farms (Leguizamón, 2016; Murmis and Murmis, 2012). Similar examples of such issues include the Brazilian-controlled land on the agro-industrial soy frontiers in Bolivia and Paraguay (Hecht, 2005; Nagel, 1999).

These investments not only lead to an increased land price but also food security issues due to the production of a commodity rather than food for the local people (Federación Agraria, 2007). In addition, as discussed earlier, soy cultivation influences resident health, e.g., increases the risk of birth malformations, cancers, skin and respiratory diseases, and other chronic illnesses due to the adoption of pesticides (Tomei et al., 2010; Benachour et al., 2007). Such impacts not only influence land usage but also create concerns about local employment.

Finally, in our reviewed articles, environmental challenges were linked with social issues. Coalition (2016) suggested that the techniques for improving natural capital should support the social licence to operate. In the context of soybean production, Fearnside (2001) noticed that soy expansion affects land use for subsistence agriculture and contributes little to reducing local unemployment. Nevertheless, our reviewed articles also indicated that environmental challenges can influence society at large. For example, Ercin (2012) found that excessive water usage in soy cultivation leaves the soil with a reduced capacity to absorb water and, ultimately, leads to flooding in some areas, which may influence residents' lives. Furthermore, the usage of pesticides in soybean production can ultimately lead to other issues (e.g., food safety and rural conflicts) that may harm the natural environment (e.g., soil quality) as well as farmer health (Waldman and Kerr, 2014; Mora, 2006).

### 3.2 Global value chain governance

Generally, the mechanisms that govern value chains or supply chains can be classified into three types: governance through chains, governance in chains and governance of chains (Bush et al., 2015).

First, normalisation needs to be considered in supply chain governance (Ponte and Gibbon, 2005). That is, stakeholders external to the supply chains or value chains (e.g., nongovernmental organisations (NGOs), government and suppliers) can shape the chains based on the norms and practices of firms (Gibbon et al., 2008; Ponte, 2009 Safarzadeh and Rasti-Barzoki, 2019a, b; Sinayi and Rasti-Barzoki, 2018).

Second, governing sustainability in chains largely emphasises the influence of private firms' activities, which refers to the managerial systems based upon performance indicators designed to improve the efficient governance of suppliers to reduce environmental (e.g., ISO 14001) and social (e.g., SA8000) risks (Bush et al., 2015; Kautto, 2006).

Finally, governance of chains refers to the conditions for market access set by lead firms (e.g., downstream buyers in developed countries) to drive changes in the production practices of upstream actors (e.g., smallholders in developing countries) (Humphrey and Schmitz, 2002; Jeppesen and Hansen, 2004). Overall, a wide range of governance mechanisms have been adopted in practice. In this paper, the first and third methods of governing supply chains are discussed.

Indeed, knowledge regarding sustainability in value chains opens avenues for understanding critical questions around the forms, functions, and impacts of governance mechanisms (Bush et al., 2015). Therefore, both public and private actors collaborate to pursue shared goals. More recently, the global value chain has been increasingly concerned with transnational private governance practices and standards for sustainable production in developing nations (Schouten and Bitzer, 2015).

Ingram et al. (2018: p.130) suggested that value chain analysis "provides a framework for mapping and categorising the interactions, relationships, and power between chain actors and the economic, social and environmental processes in chains, to create a better understanding of how and where actors are positioned and benefit or lose out." In the GVC, due to production failure, buyers are playing a central role in setting and enforcing standards (Humphrey and Schmitz, 2002). In such a context, governance over value chains refers to the collaboration among the actors within the chains and the activities and relative powers among the stakeholders within the chain (Humphrey and Schmitz, 2002). Hence, such practices require a united platform for actors, which allows them to implement collective standards.

Similarly, standards regarding sustainability can be found in business, civil society or multi-stakeholder initiatives (MSI) for products such as cocoa, soy and palm oil (Ingram et al., 2018; Schouten and Bitzer, 2015). Regulatory standards, broadly, contain government or public standards and self-governance or private standards. More specifically, public standards concern public goals, whereas private standards concern common goals that might potentially be public (Ingram et al., 2018). In other studies (Henson, 2008; Henson and Reardon, 2005; Humphrey, 2008), standards in the agri-food sector perform three different functions: first, standards can be adopted as mechanisms by which the public or private sector regulates their food system; second, standards are a mechanism to ensure that customer demand for high-quality food is satisfied or to meet environmental and ethical standards; third, standards differentiate food products in food markets (Henson, 2008; Henson and Reardon, 2005; Humphrey, 2008). In addition, managerial tools, such as the lexicographic semi-order model (LSM) (Safarzadeh and Rasti-Barzoki, 2018) and the novel linear programming model based on the flexible job-shop scheduling problem (FJSP) (Safarzadeh et al., 2018), are available to improve efficiency in sustainable chain governance. Overall, initiatives proposed by both public and private actors promote standards for better practices.

Based on our reviewed papers, we suggest that governance mechanisms can be initiated by public (i.e., national policies) or private (i.e., certification schemes) bodies. In the following sections, both public and private certificates regarding the governance of soy chains will be discussed.

### 3.3 Public governance of soy supply chains

In Latin American countries, soy generates considerable economic value. Many laws and policies have encouraged soy expansion (Cohn and O'Rourke, 2011). In Brazil's Mato Grosso state, for instance, a large amount of foreign investment to expand the soy enterprise has been secured by governmental institutions (Fearnside, 2001). In our reviewed articles, regulations that specifically focused on regulating soy production were limited. Other forms of laws are then required to regulate soy production. In the following section, the national environmental regulations relevant to soy production that are used for soybean chain governance are discussed.

#### 3.3.1 Brazilian forest code

In Brazil, the national government aims to reduce gross deforestation in the Legal Amazon by 80% by 2020 (Presidência da República, 2010). To achieve this goal, the government enacted the national Forest Code (FC) to regulate the conversion of forested land to agricultural land. The code requires private landowners in the Amazon to maintain native plant coverage of at least 80% in forests, 35% in the cerrado, and 20% in other areas (Presidência da República, 2012). Even so, the code has been criticised due to its weak enforcement and because it allowed for 88 Mha of legal deforestation, and the restoration requirement was reduced from 50 million to 21 Mha in 2012 (Gibbs et al., 2015; Soares-Filho et al., 2014). The legal deforestation in the Amazon decreased from approximately 27,000 km² in 2004 to 5000 km² in 2012 (Tomes et al., 2017).

#### 3.3.2 REDD+

In contrast to Brazil's national regulations, Reducing Emissions from Deforestation and Forest Degradation (REDD+) is an international framework created by the United Nations in 2013 to reduce deforestation (Meyer and Miller, 2015). REDD+ is a set of policies that allow governments in countries with high GHG emissions to dedicate funds to countries that seek to reduce GHG emissions by maintaining or reinstating forests (Angelsen, 2008). However, the initiative has been criticised since many countries have not been able to access REDD+ funding (Meyer and Miller, 2015).

### 3.4 Private governance initiatives

Currently, due to the high transaction costs and low returns for interest groups, increasing demand by customers for specific producer attributes, and increased concentration of food markets, the number of certifications, standards, labels and initiatives to promote sustainable production practices continues to grow (Waldman and Kerr, 2014).

Different from public governance mechanisms, private multi-stakeholder initiatives build dialogue across boundaries (Roberts, 2003). Similarly, García-López and Arizpe (2010) suggested that these mechanisms can be classified into top-down initiatives mainly conducted by large multinationals and international NGOs or bottom-up initiatives organised by actors directly involved in production (García-López and Arizpe, 2010). Previous studies have found that top-down initiatives are less effective due to state-oriented decisions, while bottom-up initiatives are more motivated to reduce the potential risks of production (Waldman and Kerr, 2014; Agrawal and Chhatre, 2007; Jollands and Harmsworth, 2007). Nevertheless, pressures from private interest groups are increasingly becoming powerful in promoting favourable initiatives, which has been referred to as the "new form of governance" (Waldman and Kerr, 2014). In coordinating with businesses, NGOs are capable of establishing rules that include more responsible business behaviour (Fransen and Kolk, 2007).

In our study, private initiatives refer to the certification schemes initiated by private actors. In the soy sector, such a mechanism may include RTRS, which is used to foster sustainability (e.g., deforestation reduction) (Forest Trends, 2015). However, this mechanism has been criticised due to problems related to definitions, criteria, and indicators that are not effectively implemented (Neeff and Linhares-Juvenal, 2017). Additionally, such initiatives led by private actors are also criticised due to their limited scope and geographic coverage, which makes them difficult to adopt widely (Elgert, 2013). In this section, the certification schemes or standards initiated by private bodies are discussed.

### 3.4.1 Amazon Soy Moratorium

The Amazon soy moratorium (ASM) was announced in 2006 and is the first voluntary agreement on zero deforestation in tropical areas and has been celebrated as very effective at containing Amazonian deforestation (Gibbs et al., 2015). Before selling soy-related products, farmers are required to meet the criteria of the ASM (ABIOVE, 2010). As a "hybrid" governance mechanism, deforestation caused by soy expansion in the Amazon is prohibited by international market actors complying with the regulatory tools of the states (Brown and Koeppe, 2013; Brannstrom et al., 2012). Most soy producers have either complied with the soy moratorium or exited the soy industry (Macedo et al., 2012; Rudorff et al., 2011; Baletti, 2014). Even so, the ASM has also been criticised because its impacts on the national soy sector are limited (e.g., the ASM does not apply to the Cerrado biome, which is suffering from a higher soy expansion rate than other biomes) (Gibbs et al., 2014).

Moratoria, as agreements between actors in the soy industry, can be very effective at the local or regional scale, but it is also challenging to identify ineffective activities in particular regions.

### 3.4.2 The Round Table on Responsible Soy (RTRS)

A significant number of the reviewed studies analysed the RTRS scheme. The

RTRS was a two-year certificate scheme developed based on the involvement of multiple stakeholders that was established by the WWF in 2006 (Lernoud et al., 2016; Garrett and Rausch, 2006). The certificate scheme sets generic principles and criteria that can be applied to GMO, non-GMO and organic soy (Heron et al., 2018). This standard concerns both environmental and social issues, which include legal compliance and good business practices, responsible labour conditions, responsible community relations, environmental responsibility and good agricultural practices (RTRS, 2009).

The RTRS is a voluntary multi-stakeholder initiative intended to address social and environmental issues. The RTRS creates standards that adopt third-party certification to verify that producers comply with criteria and to encourage firms to purchase certified products. There are five principles: "environmental responsibility", "good agricultural practices", "responsible community relations", "responsible labour conditions" and "legal compliance and good business practices" (RTRS, 2009). According to the RTRS (2009), the criteria include employee rights, land rights, respect for small-scale and traditional land use, the well-being of the local population, the protection of biodiversity and environmental impact mitigation, the maintenance of water quality and quantity, the maintenance and improvement of soil quality, and the elimination of certain banned agrochemicals.

Nevertheless, similar to other governance mechanisms, the RTRS faces several challenges, including engagement with global development NGOs in a standard-setting process and limited stakeholder involvement (Heron et al., 2018). Although the RTRS has made an effort to promote standards by engaging small farm holders, the certificate scheme was still skewed towards large-scale or well-capitalised farmers (Garrett et al., 2013).

### 3.4.3 ProTerra

ProTerra is a certificate scheme developed by Cer-ID and Genetic ID in 2004 and 2005 and is based upon the Basel Criteria for Sustainable Soy Production (Heron et al., 2018; Meyer and Cederberg, 2013). Essentially, ProTerra is a certification scheme with a quality management approach, and in collaboration with the leading actors in the agri-food industry, it designs standards to prevent the unsustainable use of soil, pesticides, water and land (Garrett et al., 2013). The scheme requires that all actors within supply chains be inspected, audited, sampled and tested before being certified.

Similarly, ProTerra includes numerous common criteria for assessing environmental and social performance (e.g., waste and pollution management, gender equity, child labour and labour conditions) (Heron et al., 2018). However, unlike RTRS, ProTerra does not allow any GM soy. Another difference lies in the methods adopted for governance: ProTerra adopted the Basel Criteria principles implemented by Cert-ID, while RTRS follows a “consensus-building” approach with stakeholder dialogue and engagement (Heron et al., 2018; Meyer and Cederberg, 2013).

### 3.4.4 Soja Plus

Nearly one year after the adoption of the RTRS principles and criteria, another major Brazilian player announced its withdrawal from the RTRS: ABIOVE. This withdrawal was a serious matter for the RTRS for two reasons. First, ABIOVE had been on the board of RTRS since its commencement. Second, the nine members of ABIOVE (including large multinationals such as ADM, Bunge, Cargill and Louis Dreyfus) together processed 72% of Brazil’s soybeans. ABIOVE left RTRS and, at the same time, launched a plan to organise a new voluntary scheme in 2011 for soybean producers of Brazil: Soja Plus.

Similar to RTRS, Soja Plus adopted a multi-stakeholder approach to address the legal, environmental, social and agricultural dimensions of soy farming systems. By referencing the RTRS standards, Soja Plus provides a methodology for regulating the environmental and social practices in Brazil’s soybean sector (ABIOVE, 2010). Soja Plus is a private initiative with close linkages to governmental regulations. In addition to referencing the RTRS, the indicators of Soja Plus were developed on the basis of the Brazilian environmental and social legislation, the ASM and the International Soybean Growers Alliance (ABIOVE, 2010). Soja Plus provides tools for producers in rural areas to comply with current regulations and provides technical support and training for farmers to achieve social and environmental goals (ABIOVE, 2010). The scheme has been promoted as a private initiative to enhance national regulations.

Soja Plus is different from the RTRS in three ways. First, since it lacks economic viability, Soja Plus also promotes economic opportunities to avoid nonessential costs and to promote economic motivations in the soy sector (ABIOVE, 2010). Second, unlike the RTRS, the criteria regarding reductions in GHG emissions, land-use conflicts and the resolution of complaints from local communities and other traditional land users are not included (Hospes, 2014). Third, unlike the RTRS, Soja Plus defines itself as a standard designed for the Brazilian context rather than the global context (Schouten and Bitzer, 2015).

### 3.4.5 Forest-Friendly Soy Pilot Project

The Nature Conservancy's (TNC) Forest-Friendly Soy Pilot Project was developed to address environmental and socioeconomic issues and certify forest-friendly soy for major soy buyers in Brazil in 2004 (TNC, 2004). The initiative seeks to tackle deforestation in the Amazon by ensuring that soy producers comply with relevant regulations (TNC, 2004). Additionally, the initiative requires farmers to follow Brazil's Forest Code to tackle potential threats and secure themselves against reputational risks (TNC, 2004). As this initiative mainly addresses deforestation, it is limited to considering non-forest areas in agribusiness. As a result, the initiative does not effectively solve the high forest bias problem or environmental issues in secondary forest areas (Steward, 2007).

In summary, as many negative issues exist in soy cultivation, efforts have been made by both public and private bodies. Collectively, studies addressing the relationships among these initiatives, especially the relationship between public and private initiatives, are still lacking. It is unclear whether a linkage between these initiatives exists. If such a linkage exists, how are the initiatives collaborating? Both issues are displayed in Table 5.

**Insert Table 5 about Here**

Given that NGOs may provide guidelines and policies for companies to comply with, implementation cannot be ensured. When governments are engaged in such initiatives, the enforcement and implementation of such standards may be improved and, ultimately, lead to better compliance (Kantz, 2005).

### 3.5 Consequence

Taken as a whole, the certification schemes discussed above are all designed to improve the sustainability of soy production. In this section, the outcomes of the initiatives are discussed.

In our reviewed certification schemes, generally, all sought to contribute to sustainable and responsible soy production by promoting standards to mitigate environmental and social risks (e.g., legal compliance, labour conditions, and pollution management) (Heron et al., 2018). In terms of the environmental impacts, these schemes are effective in making positive environmental impacts. The consumption standards for agrochemicals proposed by the RTRS, for instance, are reducing risks to human and animal health and the natural environment. However, the macro impacts of soy cultivation (e.g., GHG calculations) cannot be mitigated by certification schemes alone (Tomei et al., 2010). Likewise, the land-use conflicts caused by soy production cannot be resolved by implementing voluntary standards alone (Tomei et al., 2010). In summary, given that the initiatives or certification schemes are attempting to promote more sustainable soy production practices, their improvement of sustainability at the macro level is still questionable. It is therefore suggested that future research explore how such initiatives can be more effective in making macro impacts.

The implementation of sustainability initiatives leads to mitigation of potential social risks, such as the loss of reputation or public creditability (Waldman and Kerr, 2014). However, it is still suggested that certification schemes (e.g., RTRS) alone are insufficient to create appropriate public policies that protect health and food security for the broader society without long-term policy development (Tomei et al., 2010). It is challenging to measure the efficiency of certificate schemes (Cohn and D. O'Rourke, 2011). Generally, the efficiency and impact of certificate schemes are determined by the enforcement and implementation rate. On the one hand, from the perspective of policymakers, limited funding leads to the short-term adjustment of policy development, which means that private interests are usually ignored (Tomei et al., 2010).

In addition, local priority are another influential factor in policy development and implementation (Tomei et al., 2010). In Brazil, for instance, limited enforcement of regulations and private supply chain initiatives led to legal deforestation (i.e., limited outcomes) (Gibbs et al., 2015). Likewise, from the perspective of producers, the effectiveness of supply chain initiatives depends on the degree to which supply chain actors participate in collaborative efforts. In this regard, the efficiency of improving environmental and social sustainability through collaborative efforts can be influenced by customer awareness (Gertz, 2005), farmers' willingness to stick to the scheme when the profits are more than the costs of implementation (Campbell, 2005), producers' knowledge on certification schemes (Meijer, 2005) and other influential factors. As producers need to consider the unclear benefits of the RTRS (Meijer, 2005), they may not be willing to adhere to the scheme. For these reasons, the certificate adoption rate for soybeans remains low, which limits its impacts on both production and policy-making processes. Following the discussions above, potential barriers still exist when implementing the initiatives.

### 3.6 Potential barriers

As discussed above, in our reviewed articles, both public and private initiatives can lead to more sustainable governance of soy production. However, such practices are still constrained by numerous barriers that are internal or external to the mechanisms. In this section, the potential barriers to these mechanisms are discussed.

The first potential barrier might be that private initiatives lack downstream demand from customers (Heron et al., 2018). In this way, the organisations that represent the demand of "customers" (e.g., NGOs) are making efforts to develop certification schemes for soy to tackle sustainability issues (e.g., deforestation) and other activities that have put pressure on supply chain actors (e.g., ASM). Even so, it is still challenging to address the complex demands of various stakeholder groups (Heron et al., 2018). For instance, the RTRS lacks requirements on segregation and has been criticised concerning its skew towards large-scale producers (e.g., Grupo Maggi), while small-scale actors are comparatively ignored due to the costly certification and auditing process provided by the certificate body (Bennett, 2017).

Second, soy is a low-visibility commodity; there is no requirement for identification on meat labels of the source of the soy used in raising the meat (Heron et al., 2018). The coverage of sustainable certificate schemes is still limited. To date, ProTerra and the RTRS are the largest and most influential soy certification schemes (Van der Van et al., 2008). RTRS, for instance, only certified 1% of the soybeans in the global marketplace (RTRS, 2017; Virah-Sawmy et al., 2019). In Brazil, less than 1% of soy production (in terms of both production area and volume) was RTRS certified in 2013 (RTRS, 2017). In a similar vein, of the total non-GMO soybean production in the global agricultural market, approximately 9% was certified by ProTerra, as the certification cost accounts for 5% to 10% of the price of soybeans (Garrett et al., 2013). However, because the benefits (especially financial benefits) are uncertain, producers are not willing to certify their products (Meijer, 2005). Additionally, as the implementation of sustainability initiatives can be pushed by supply chain actors, the coverage rate can be improved if the actors in the soybean chain are more willing to purchase products from certified suppliers or push their suppliers to certify their products. However, although a large number of soy products are used for animal feed (i.e., a large number of supply chain actors can be identified in the soybean chain), meat producers are not willing to change their upstream supply chains, as soybeans are invisible to their consumers (i.e., they are not making efforts to certify their suppliers) (Schouten and Glasbergen, 2012). A similar situation also occurs in other crops (e.g., WWF's RSPO initiative for sustainable palm oil production) (Meijer, 2005). Therefore, from the customer perspective, there might be low awareness of the certification schemes or questions about why such certification schemes are necessary. Hence, there is a broad marketplace for uncertified soy, meaning incentives for a transition to certified soy are undermined. Additionally, certified products are not well differentiated from those with no labels. That said, the low demand or weak awareness of the certification schemes and sustainable soy production in the marketplace is another barrier to the implementation of such schemes.

In other studies, a potential barrier from the external institutional environment might be that MSIs (especially private initiatives) can conflict with national regulations or other existing standards. One example of this is that in Brazil, the planned reform of the national forestry code (NFC) increases the cost for soybean producers to participate in the RTRS. In this sense, once again, small-scale soy producers have more difficulties complying with the certificate scheme due to the higher costs of compliance (Schleifer, 2016). Likewise, a conflict might occur when the regulations conflict with the definitions in the current legislation or industrial standards when producers adopt or comply with more sustainable practices (Meyer and Miller, 2015). In these cases, the compliance or implementation of MSIs, especially private initiatives, can be "constrained" by existing formal institutions. However, the understanding of how certificate designers can identify and mitigate the risks of conflicting with existing institutions is still limited.

## 4. Towards a conceptual framework

Based on the above discussions, in the following section, a conceptual framework regarding the themes and their relationships is demonstrated in our proposed framework.

**Insert Figure 4 about Here**

As shown in Figure 4, on the left side of the framework, the drivers of implementation of sustainable value chain governance mechanisms (i.e., economic, environmental and social challenges) are illustrated. The proposed model also indicates the linkage between economic and environmental challenges (e.g., deforestation is mainly caused by soy expansion for economic profits). Additionally, we found that both economic and environmental drivers lead to numerous social risks (e.g., soy expansion driven by cost reduction leads to the employment of forced labour, while land-use conflict leads to negative impacts on the livelihood of farmers in rural areas).

Both public and private initiatives have been used to tackle these challenges. As both types of mechanisms have their advantages and drawbacks, they also influence each other. Soja Plus, for instance, was developed by referencing national regulations. Vermeulen et al. (2008) and Altenburg (2007) suggested that among public regulations, taxation policies, national regulations, trade policies and regulations of property rights may influence firms' attitudes towards sustainability initiatives. That said, an external institutional environment can affect or shape the acceptance or implementation of non-state standards.

Based on the discussions above, it was found that both mechanisms interacted with each other. On the one hand, as a traditional governance mechanism, country policy provides an institutional environment before the implementation of standards initiated by private bodies. On the other hand, private initiatives fill the gaps existing in public initiatives, while public regulations provide an institutional environment for private initiatives. Therefore, we suggest that there is an inter-linkage between public and private initiatives. On the right side of this framework, the outcome of these practices (i.e., sustainability) is presented. However, the outcomes are potentially influenced by the two moderating factors of the limitations of market conditions and the mechanisms.

## 5. Managerial implications and research agenda

Based on our review of the existing literature, thematic analyses are illustrated above. However, this study sought to develop a holistic review of the existing literature as well as to open avenues for future studies. In this section, directions for future research and implications for policymakers and managers are presented.

### 5.2 Future research directions

Many of the abovementioned certificate schemes (e.g., RTRS) were designed to tackle environmental and social issues in soybean production. In this context, a considerable number of studies have focused on the ecological system surrounding soybean production, and many of these issues (e.g., deforestation) have been explicitly discussed, while research on the social aspects of sustainability lags behind. More specifically, in our reviewed articles, food safety, loss of reputation, child labour and other social issues still exist in the soybean sector (Waldman and Kerr, 2014; Newton et al., 2013). Although a couple of social impacts have been identified, few studies have investigated the strategies for how these impacts can be mitigated. Therefore, we suggest that more studies can focus on social sustainability in the soybean supply chain.

First, as discussed earlier, the challenges caused by soybean production in Brazil and China are numerous. In our reviewed works, comparative studies addressing the challenges caused by unsustainable soybean production in multinational contexts were absent. Thus, it is suggested in this study that future research should attempt to investigate such complex phenomena more holistically and to discuss the issues caused by unsustainable soybean production in a global context.

Second, most of the studies in our reviewed literature, such as Heron (2018), Fearnside (2001) and Fearnside (2003), were conducted based on the Brazilian context, followed by Argentina. However, other producing countries, such as the USA, China, and Bolivia, are major soybean producers, and research in these countries is still limited. Cross-country comparisons are rarely observed. Hence, we argued that the studies conducted in these countries and across different countries were important directions for future research.

Third, although many studies have addressed the negative impacts of soy cultivation, questions regarding how positive influences are initiated by these activities and regulatory standards remain unanswered. Additionally, as mentioned earlier, both public and private initiatives have their advantages and drawbacks. After reviewing the existing literature, we noticed that private initiatives play a supplementary role in sustainable soy supply chain management at the early stages, while public initiatives provide guidance for the private initiatives (i.e., private initiatives need to be developed under regulations proposed by governmental organisations). However, questions regarding how public and private initiatives are making collaborative efforts to promote sustainability in the soy sector remain unanswered.

Fourth, in our reviewed literature, we noticed that WWF's RTRS certificate scheme was the most studied, followed by ProTerra and Soja Plus. In existing works, we noticed that TNC's Forest-Friendly Soy Pilot Project, the Danube Soy Initiative and other initiatives were rarely covered. However, studies have shown that TNC's initiative in the sustainable soy sector is one of the main initiatives improving environmental protection practices (Steward, 2007). Nonetheless, the studies related to this certification scheme are limited. Hence, we suggest that more studies can be conducted on other alternative initiatives rather than the ones we reviewed in this work. In addition, studies addressing the relationships among these initiatives, especially in the multinational context and those between public and private initiatives, are still lacking. It is unclear whether there is a linkage between these initiatives. If there is a linkage, how do these initiatives collaborate? Future research can investigate these topics.

Fifth, according to the proposed conceptual model and reviewed literature, it was illustrated that the market demand and limitations of the sustainability initiatives in the soybean sector influenced the implementation of public and private initiatives. However, it is still unclear how these barriers influence the effectiveness of the initiatives and the consequences. Hence, in line with this, more studies may be devoted to addressing the potential barriers to sustainability initiatives in the soybean sector and the degree to which these barriers influence the efficiency of value chain governance. Similarly, as discussed earlier, three types of challenges were identified as the drivers of sustainable value chain governance. The reviewed articles did not provide detailed discussions about the relationship between economic, environmental and social challenges. In this regard, more studies can be carried out to explore the relationship between these aspects of the challenges.

Sixth, as a tool to assess the environmental impacts of a product, life cycle assessment (LCA) can also be used to assess soybean production. Griffing et al. (2006) carried out an LCA case study on processing soybeans into soybean oil and suggested the utilisation of LCA as a tool for material selection and process improvement. However, as for other agricultural products, the application of LCA to estimate all aspects of production is challenging due to the complicated agricultural system and dynamic external issues (e.g., climate and soil quality) (Eranki et al., 2019). Under the context of soybean production, as soybeans can be processed into a wide range of products, future studies might pay more attention to the application of LCA for cleaner production of soybean products (e.g., soy sauce) and better assessments of the production process for soybean products (e.g., transportation of soy milk).

Finally, in our reviewed articles, we found that prior works largely adopted case studies and modelling as methodologies, while other methods (e.g., surveys) or quantitative secondary data were relatively rarely used. Therefore, we also suggest that more studies adopt other methods rather than case studies and modelling in the future. To summarise, the research gaps and directions for future study are illustrated in Table 6.

**Insert Table 6 about Here**

### 5.2 Managerial implications

As discussed earlier, the challenges in soy-producing countries vary. Hence, the dimensions of "sustainability" can be defined by policymakers and managers in different ways.

First, from an international trade perspective, Taherzadeh and Caro (2019) found that approximately one-third of the water and land consumption of soybean production was driven by international trade, of which 70% was used for animal feed, one-fourth (24%) was used in food products and only 2% was lost in the distribution of the soybeans. In this regard, "sustainability" under the context of international trade stands for mechanisms that reduce water wastage during the process of animal feed and food production. Additionally, in South America (especially in Brazil), unsustainable soy expansion has led to deforestation, land-use conflict and other relevant issues (e.g., GHG emissions, centralisation of land and financial difficulties for farmers). In line with this, "sustainability" refers to cleaner production tackling deforestation and well-balanced land use considering the ecological and social impacts.

Second, in Argentina, as more labour-replacing positions have been introduced during soy expansion, access to land (Leguizamón, 2016; Murmis and Murmis, 2012) and the job market for low-skilled local farmers are limited (Phélianas and Choumert, 2017). Hence, in Argentina, "sustainability" for policymakers refers to more well-balanced land use regulations, more opportunities for low-skill farmers and a "smooth" transition for farmers (e.g., from low-skilled to high-skilled labour) and the soybean industry (e.g., from a labour intensive to capital intensive industry). Likewise, land-use conflict also occurs in Bolivia and Paraguay and requires policymakers to develop more effective regulations. In China, large-scale soy production led to the degradation of water and soil, GHG emissions and biodiversity losses (Schneider, 2014; Yan et al., 2016; Liu et al., 2019), which means that shifting to cleaner or more sustainable soy production poses the main challenge.

Third, from the perspective of the managers in the soybean sector, public and private initiatives have their advantages and drawbacks. Specifically, public standards are more likely to concern public goals, while private initiatives are more likely to address the concerns that could be potentially addressed by the public (Ingram et al., 2018). In these senses, public initiatives are more powerful to implement, whereas private initiatives are more customer oriented. In this sense, managers can take advantage of two types of sustainability initiatives to develop well-balanced and certified production systems. Additionally, a wide range of techniques has been adopted to increase yields and achieve more sustainable production, which includes GM soybean production (Qaim and Traxler, 2005; Zak et al., 2008) and no-till cultivation (Huggins and Reganold, 2008). Hence, overall, managers in the soybean sector can use existing standards and techniques to improve the yields and sustainability of their production, while the application of LCA is desirable to promote cleaner production.

## 6. Conclusions

In this study, we performed a systematic review of sustainable soybean supply chain management. After reviewing the existing literature, this study identified the following themes: drivers (i.e., economic, environmental and social challenges), soy value chain governance, mechanisms (i.e., public and private initiatives), consequences and potential barriers. Furthermore, as the relationships among the themes were identified, a conceptual framework was proposed. Finally, several gaps and implications for the existing knowledge have been identified to provide directions for future research.

The theoretical contribution of this study was threefold. First, it might be the first holistic literature review to discuss sustainable soybean supply chains. Second, after reviewing the existing literature, a conceptual framework was proposed, which contributes to deepening the understanding of sustainability issues in soybean supply chain management. Finally, considering the gaps identified in existing knowledge, this review paper also provided numerous directions for future studies.

However, this study is not without limitations. First, our reviewed certification and other regulatory standards only consisted of initiatives developed in soy exporting countries, and we did not consider those developed by soy importing countries. Second, in terms of language selection, our selected literature was limited to English. However, a certain number of studies in other languages (e.g., Portuguese) were excluded from this paper. Therefore, future studies should include existing literature written in these languages. Third, our proposed conceptual framework was developed based on the reviewed articles rather than on empirical data. Hence, it is suggested that future work can carry out empirical studies to test the proposed conceptual model.

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Figure

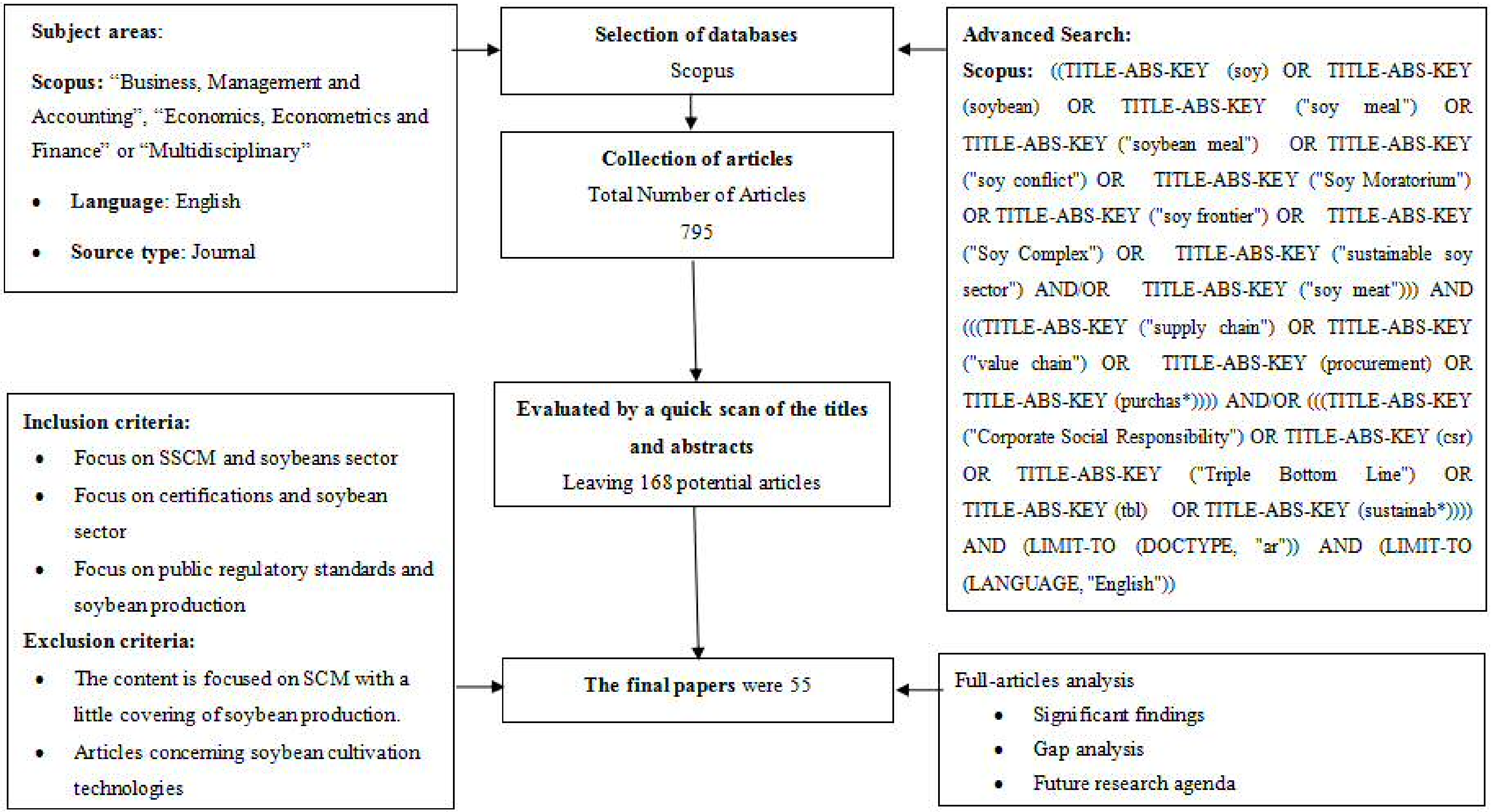


**Figure 1.** Review Process

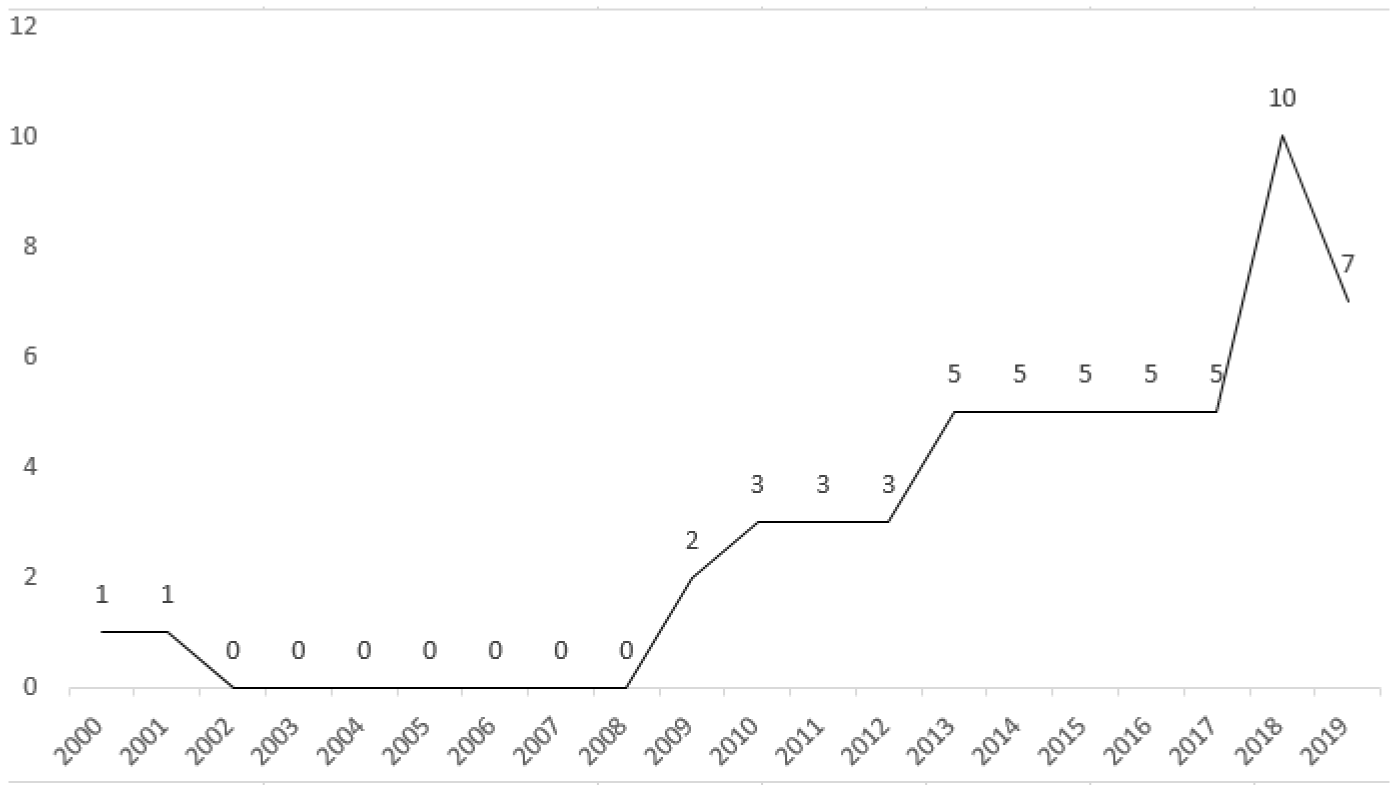


**Figure 2** Distribution of Reviewed Articles by Year (N=55)

**Table 1** Description of Journals with More than Two Reviewed Papers

| Journal | Number of Papers | Impact Factor | Quartiles |
|---|---|---|---|
| Journal of Cleaner Production | 7 | 6.395 | Q1 |
| The Journal of Peasant Studies | 5 | 4.331 | Q1 |
| Land Use Policy | 4 | 3.573 | Q1 |
| Ecological Economics | 3 | 4.281 | Q1 |
| Applied Geography | 2 | 3.068 | Q1 |
| Environment, Development and Sustainability | 2 | 1.676 | Q2 |
| Environmental Research Letters | 2 | 4.541 | Q1 |
| Global Environmental Change | 2 | 10.427 | Q1 |
| Journal of Sustainable Forestry | 2 | 0.747 | Q2 |
| Journal of Transport Geography | 2 | 3.560 | Q1 |
| World Development | 2 | 2.848 | Q1 |
| Agriculture and Human Values | 1 | 2.568 | Q1 |
| Annual Review of Resource Economics | 1 | 2.978 | Q1 |
| Applied Energy | 1 | 8.426 | Q1 |

| | | | |
|---|---|---|---|
| Biomass and Bioenergy | 1 | 3.537 | Q1 |
| Ecological Indicators | 1 | 4.490 | Q1 |
| Energy | 1 | 5.537 | Q1 |
| Energy Policy | 1 | 4.880 | Q1 |
| Environment and Planning A | 1 | 1.389 | Q1 |
| Environmental Biosafety Research | 1 | N/A | N/A |
| Environmental Conservation | 1 | 2.759 | Q1 |
| Environmental Management | 1 | 4.865 | Q1 |
| Global Policy | 1 | 0.603 | Q1 |
| Globalizations | 1 | 1.671 | Q1 |
| Governance | 1 | 3.833 | Q1 |
| Journal of Ambient Intelligence and Humanized Computing | 1 | 1.910 | Q2 |
| Journal of Decision System | 1 | 3.847 | Q3 |
| Journal of Environmental Management | 1 | 4.865 | Q1 |
| Mitigation and Adaptation Strategies for Global Change | 1 | 2.651 | Q1 |

| | | | |
|---|---|---|---|
| Nature Climate Change | 1 | 19.181 | Q1 |
| Sustainability | 1 | 2.075 | Q2 |
| Sustainability Production and Consumption | 1 | N/A | Q1 |
| Tropical Conservation Science | 1 | 1.149 | Q2 |

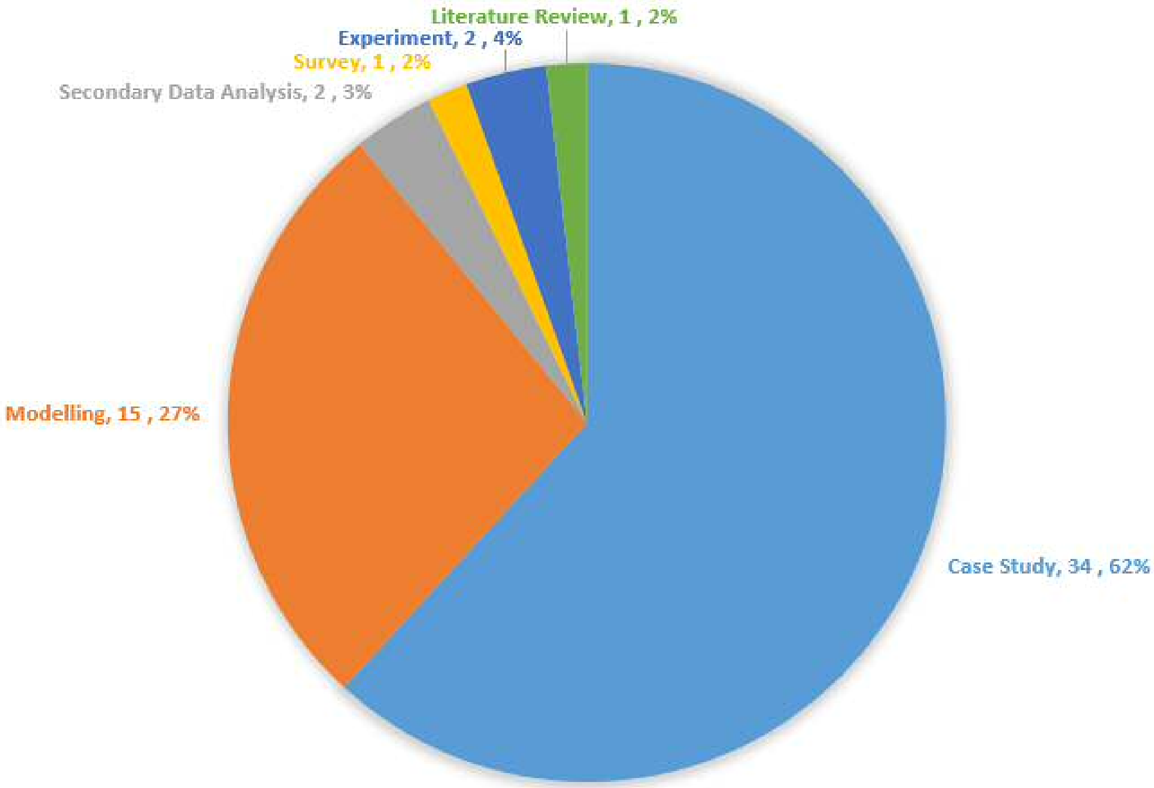


**Figure 3** Distribution of Reviewed Articles by Method

**Table 2** Description of Economic Driver

| Drivers | Description | Country Recorded | Reference |
|---|---|---|---|
| Economic value creation | It refers to the economic value created by productions related to soybean cultivation (e.g., infrastructure) | Brazil | Garrett et al. (2013) and Barros et al. (2011) |
| Economic performance of soybean cultivation | Costs or profitability of different type of soy-related products. | Brazil | Antoniou et al. (2012) and Azadi and Ho (2010) |
| Cost optimization | It refers to cost reduction or minimization in soy production | Brazil | Reis and Leal (2015), Silva and Marcio de Almeida (2013) |

**Table 3** Description of Environmental Drivers

| Drivers | Description | Country Recorded | Reference |
|---|---|---|---|
| Land consumption and land use conflict | The conflicts between the increasing demand for land while the amount is limited (e.g., increased land price in soy production areas). | Argentina, Bolivia and Brazil | Garrett et al. (2013), Garrett and Lambin (2013), Garrett and Naylor (2013), Tomei et al. (2010), Weinhold et al. (2013) and Zak et al. (2008) |
| Greenhouse gas emission | The increased amount of GHG emissions (e.g., carbon dioxide) caused by soybean cultivation. | Brazil | Borzoni (2011), He et al. (2019), Newton et al. (2013), Tomei et al. (2010) and Reijinders and Huijbregts (2008) |
| Deforestation | The reduction of tropical forests due to the increasing amount of land used for soy cultivation. | Brazil | Arima et al., (2011), Cohn and O'Rourke (2011), Delgado (2012), Fearnside (2001), Macedo et al., (2012), Oliveira (2016) and Sauer and Leite (2012) |
| Loss of carbon and climate change | The GHG emissions and climate change caused by deforestation. | Brazil | Fearnside et al. (2013), Huijbregts (2008) and Liu et al. (2019), |
| Impact on water quality | Influences levels of water flow, sediment and temperatures. | Brazil | Macedo and Coe, (2013) and Neill et al., (2013) |

| | | | |
|---|---|---|---|
| Water consumption | Soy cultivation consumes a large number of water resources | Brazil, Canada, France, China and United States | Ercin et al., (2011) and Taherzadeh and Caro (2019) |
| Soil quality | Capacities of soil influenced by water usage in soy production | Brazil | Lal et al., (2007), Marraro (2004) and Monti (2008) |

**Table 4** Description of Social Drivers

| Drivers | Description | Country Recorded | Reference |
|---|---|---|---|
| Reputation | Environmental, social or other issues are affecting soy producers' sales or bottom line. | Brazil | Newton et al. (2013) |
| Child labour or forced labour | One of the issues affecting employees' well-being. | Brazil | Waldman and Kerr (2014) |
| Poverty | Food-insecure families were worried that their food would run out before they received more money, could not afford to purchase balanced meals and relied | Brazil | Elgert, 2016, Garrett et al. (2013) and Reis (2012) |

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| | on low-cost foods for children. | | |
| Rural livelihood | New positions created in soy sector can be acquired by immigrants rather than residents as they require particular skills | Argentina, Bolivia and Brazil | Berry, 2010, Chase (1999), Fearnside (2008), Phélianas and Choumert (2017), Sawyer (2008) and Zoomers (2010) |
| Land use conflict | The land has been controlled by foreigners rather than local investors | Brazil, Bolivia and Uruguay | Garrett et al. (2016), Hecht (2005), McKay (2018), Medina et al. (2016) and Nagel (1999) |
| Food security | It is on the production of commodities rather than food for local people | Argentina | Federación Agraria (2007); |
| Health impacts | Soy cultivation increases the risk of birth malformations, cancers, skin and respiratory diseases and other chronic illnesses. | Argentina and Paraguay. | Salomon et al. (2006), Seijo (2008), Tomei et al. (2010), Benachour et al. (2007), WB/FAO (2004), FODEPAL (2005), Waldman and Kerr (2014) and Mora (2006) |

**Table 5** Comparisons of Reviewed Soy Governance Initiatives

| Initiative | Certification Body | Established Year | Geographical Coverage | Purposes of the Initiative | Limitations |
|---|---|---|---|---|---|
| Brazilian Forest Code | Brazilian Government | 1965 | Brazil | A national law to regulate consumptions of forestry land caused by productions (e.g., soy cultivation). | Low enforcement and permission of legal deforestation. |
| REDD+ | United Nations | 2013 | Global | Is an internationally accepted framework to tackle deforestation | Limited access to obtain funding in many countries. |
| Amazon Soy Moratorium | Mass soy traders and NGOs | 2006 | Global | It is the first voluntary agreement on addressing zero-deforestation in the tropical area. | Limited impact on the national soy sector. |
| RTRS | WWF | 2006 | Global | It is designed to address environmental and social issues in soy production, which includes, employees' rights, land rights, respect for small-scale and traditional land use, well-being of local population, protection of biodiversity and environmental impact mitigation, maintenance of water quality and quantity, maintenance and improvement of soil quality, and the elimination of certain banned agrochemicals. | Skewed toward large-scale or well-capitalized farmers.<br><br>High certificate cost for small-scale producers.<br><br>Limited stakeholder involvement. |

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| ProTerra | Cer-ID and Genetic ID | 2004 | Global | It is used to assess environmental and social performance (e.g., waste and pollution management, gender equity, child labor and labor conditions) in soy production. | Standard only designed for Brazilian context rather than a global context. |
| Soja Plus | ABIOVE | 2011 | Brazil | It provides environmental and social practices, a guideline of compliance of national regulations and economic opportunities to avoid unessential costs for Brazil's soybean sector. | Criteria regarding reductions of GHG emissions, land use conflict and resolutions for complaints of local communities and other traditional land users are not included. |
| Forest Friendly Soy Pilot Project | TNC | 2004 | Global | The initiative seeks to engage farmers to tackle deforestation in Amazon by ensuring soy producers to comply with Brazil's Forest Code to tackle potential threats and secure themselves against reputational risks. | Failure to address the environmental impacts of soy production in secondary forest areas. |

**Table 6** Research Gaps and Directions for Further Studies

| Theme | Research Gaps | Future Research Directions |
|---|---|---|
| Drivers | Lack of research in the social aspect of sustainability. | More studies addressing social sustainability in the soybean supply chain, especially discussions over the mechanisms behind these phenomena, are required in future research. |
| | Understandings of challenges caused by soybean cultivation in a multi-national context are limited. | Future research can make more efforts to investigate such complex phenomena more holistically to discuss the issues caused by unsustainable soybean production in a global context. |
| | Lack of studies conducted outside of tropical regions (Brazil and Argentina). | More research can be conducted in other soy-producing countries, such as USA, China and Bolivia |
| | Negative effects of unsustainable soy cultivation were being discussed while another side remains blank. | Further studies should be addressing the positive consequences of sustainable soy cultivation. |
| Global value chain governance | Better practices on public-private partnership in soy sector were rarely mentioned in existing works. | More studies should be designed to answer the following questions: how such mechanism is making collaborative efforts on promoting sustainability |
| Certificate scheme | Most of our reviewed discussed WWF's RTRS certificate schemes followed by ProTerra and Soja Plus, while discussions on other relevant certificate schemes are lagged behind. | Discussions on other relevant certification schemes (e.g., TNC's Forest Friendly Soy Pilot Project, the Danube Soy Initiative, FEFAC Soy Sourcing Guideline) are desired. |

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| | Studies are addressing the relationships different initiatives, especially in the multi-national context and the relationship between public and private initiatives, are still lacking. | Future research can investigate these relationships if they exist. |
| Potential barriers | The current understandings of the relationship between barriers and effectiveness of sustainable initiatives in the soybean sector are limited. | Future research needs to address other potential barriers that influence the effectiveness of the initiatives and to what degree it can influence efficiency. |
| Other emerging themes | Understandings of applications of LCA in soy productions is still lacking | More studies are needed to address how LCA can be used as a tool to facilitate soy productions at the process or product level. |
| | A large number of reviewed articles used case study and modelling as methodology | more studies adopt other methods rather than case study and modelling in the future. |

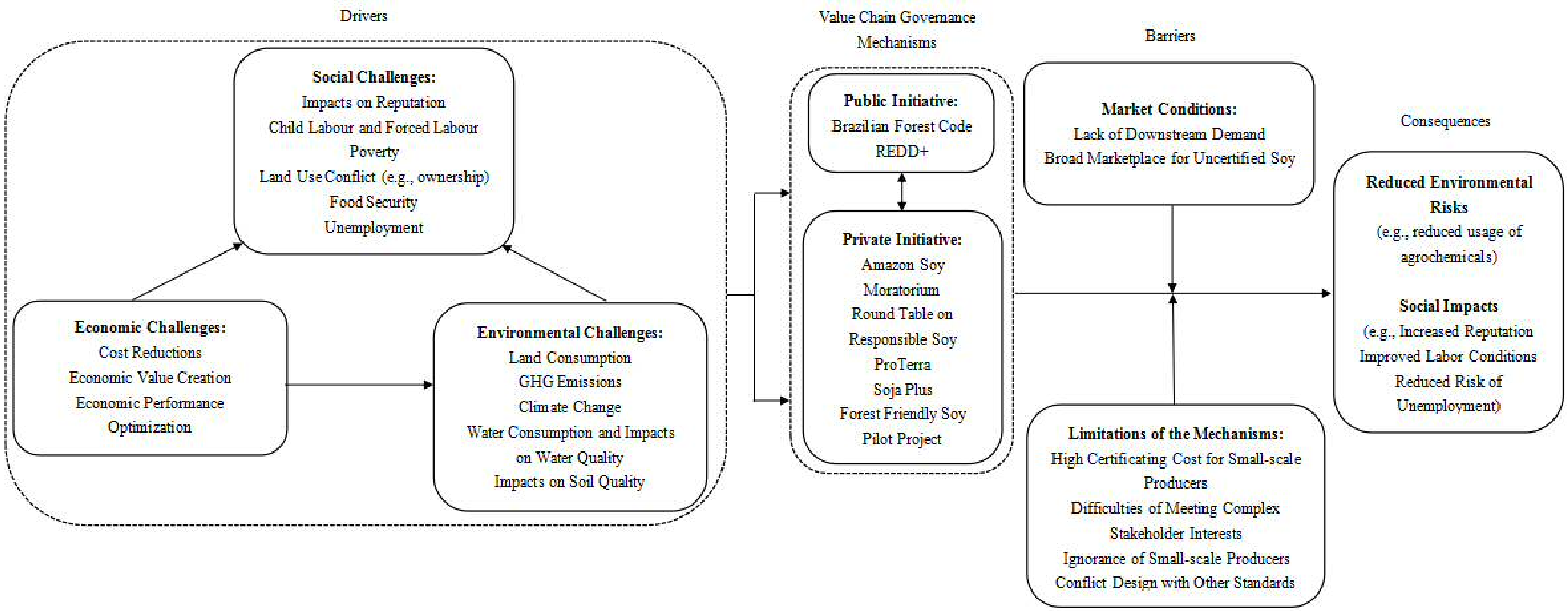


**Figure 4** Proposed Conceptual Framework

**Appendix: Dof all the reviewed papers**

| No. | Author | Result | Method | Country | Theory |
|---|---|---|---|---|---|
| 1 | Arima et al. (2011) | Based on the investigation of land-use change in Brazilian Amazon, the results revealed that the land-use linkages in agricultural sector need to be realised by the government. Also, global efforts of reducing GHG gas emissions need to be made in response to the increasing demand for Brazilian agricultural products. | Modelling | Brazil | No |
| 2 | Arizpe et al. (2014) | This study assessed the agricultural changes in rural communities in North Argentina. By concluding, this article argued that both ecological (e.g., deforestation) and social (e.g., fair wage) need to be addressed. | Case Study | Argentina | MuSIASEM approach |
| 3 | Baletti (2014) | Through an analysis of the mechanisms and effects of two programs, implemented through partnerships between non-governmental organizations and corporations, to manage soy expansion into the Amazon, it is demonstrated that these programs have questionable environmental benefits at best and at worst work to reinforce the hegemony of international environmental organizations, to green the image of agri-business multinationals, and to destabilize strategies of resistance. | Case Study | Brazil | No |
| 4 | Bennett, 2017 | This study the effectiveness of Socially-oriented Voluntary Sustainability Standards (VSSSOs), suggesting that diversified global economic governance provides opportunities to bring new perspectives to the decision-making of VSSSOs. | Case Study | No | No |

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| 5 | Borzoni (2011) | This study carried out a multi-scale integrated assessment of soybean biodiesel in Brazil. The results show that soybean biodiesel increases energy consumption per hour of work without a corresponding increase in economic labor productivity. Consequently, the already low energy efficiency of Brazilian production could get worse. Although Brazil has large expanses of land, the substitution of 20% fossil diesel (i.e. just 3.3% of the country's primary energy consumption) with fully renewable biodiesel might destroy protected areas and forests and increase the GHGs emitted. | Modelling | Brazil | No |
| 6 | Brannstrom et al. (2012) | This study proposed a framework focusing on the interactions among state and non-state actors to address the effectiveness of "soft" governance. The conclusion is that the policies bridge the gap between environmental and agricultural interests. However, the effectiveness can be influenced by the effect of globalisation, market and state actors. | Case Study | Brazil | No |
| 7 | Bush et al. (2015) | This study reviewed the sustainability governance by concluding that the literature on global chain and networks has yet to be adequately conceptualised. In this regard, a typology was proposed to identify how firm and non-firm actors govern sustainability in global commodity networks. | Literature Review | No | No |
| 8 | Cohn and O'Rourke | This study discussed the agricultural certification tools in Latin America and found that certification faces greater challenges than other voluntary conservation schemes due to the little concerns from influential supply chain actors. To increase the effectiveness of certifications, potential risks (e.g., timeless and safety) need to be considered, so that they could be mitigated and supply chain actors can be involved. | Case Study | Brazil | No |
| 9 | da Silva, and Almeida D'Agosto (2013) | This article proposes a model to estimate the origin-destination (O–D) matrix for the export flow of Brazilian soybeans based upon a constrained gravity model. The performance of the model was improved by establishing an adjustment criterion for the data, which increased the coefficient of determination of the trend by 24–46%, combined with multi-objective optimization techniques to ensure a balance of the O–D matrix, which yielded R2 values of 0.94 regardless of the prediction year. The model is easy to apply and can help in | Modelling | Brazil | No |

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| | | the strategic planning of transportation for the export of soy products from Brazil, provided that the supply chain configuration is known and the absolute percentage errors are monitored over time. | | | |
| 10 | Elgert (2015) | It is a case study focusing on sustainable soy in Paraguay. The author suggested that stronger sustainability can be claimed by redressing the equity issues marginalised by neoliberal agriculture. | Case Study | No | Paraguay |
| 11 | Eranki et al. 2019 | This study analysed the carbon footprint of corn-soy-oats in the US and found that the N2O contributed the most significantly to the total carbon footprint in the on-farm areas, which is also depending on the yield of the crop. | Experiment | United States | No |
| 12 | Ercin et al. (2012) | This study investigated the water footprint (WF) of two soy products (i.e., soy milk and soy burger) and found that the transition from non-organic to organic framing reduces the grey WF by 98%. In addition, the total WF of soy milk and soy beef is much larger than other soy equivalents. | Experiment | Canada, China and France | No |
| 13 | Fearnside (2001) | This study carried out a case study regarding the unsustainable soy expansion and argued that the multiple impacts of soybean expansion on biodiversity and other development considerations have several implications for policy: (1) protected areas need to be created in advance of soybean frontiers, (2) elimination of the many subsidies that speed soybean expansion beyond what would occur otherwise from market forces is to be encouraged, (3) studies to assess the costs of social and environmental impacts associated with soybean expansion are urgently required, and (4) the environmental-impact regulatory system requires strengthening, including mechanisms for commitments not to implant specific infrastructure projects that are judged to have excessive impacts. | Case Study | Brazil | No |
| 14 | Fearnside et al. (2013) | This paper finds that the rapid rise in exports of soy and beef products to China are two of the major drivers of Amazonian deforestation in Brazil. The paper further argues that Chinese purchases of agricultural and forest land and Chinese imports of commodities such as timber and aluminum also cause environmental impacts in Amazonia. Chinese financing and investment in Amazonian infrastructure such as railways and | Modelling | Brazil | No |

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| | | mineral processing facilities have additional impacts. | | | |
| 15 | García-López and Arizpe (2010) | It is a case study regarding the participatory process in soy conflicts in Paraguay and Argentina. The author suggested that the bottom-up approach can be used to promote true agricultural sustainability and the research on the grassroots participatory process and their limitations need to be addressed in future research. | Case Study | Argentina and Paraguay | No |
| 16 | Garrett and Rausch (2016) | It is a case study regarding the social and ecological tradeoffs of the sustainable soybean sector in Brazil. In conclusion, it is suggested that the Brazilian soy production performs as well as or better than other crops in terms of local economic development, land use efficiency and macroeconomic contribution. However, the tradeoffs between economic contributions, ecological and social influences are still involved. | Case Study | Brazil | No |
| 17 | Garrett et al. (2013) | By exploring the economic geography land-use change in Brazilian Amazon, this study concluded that the occurrence of agglomeration economies is influenced by various environmental and land tenure in different regions. In this, supply chains become more competitive and divers in Sorriso where few environmental regulations existed, while the diversity of supply chains is reduced by environmental regulations Santarém. In addition, the supply chain model in different regions also led to different degrees of productivity, innovation and soy expansion. | Case Study | Brazil | Thunian Theory |
| 18 | Garrett et al. (2013) Ab? | This study discussed the impacts on soybean production in South America by linking the preferences for non-genetically modified crops, eco-certification, and land use. It is suggested that the availability of financial incentives for protecting forests, reducing greenhouse gas emissions and other green practices should be encouraged. Nevertheless, it is also found that mismanagement may exist during the implementation of sustainable certifications (e.g., producers who historically deforested may be reworded). | Modelling | Argentina, Bolivia, Brazil, Canada, Paraguay, Uruguay and United | No |

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| 19 | Gollnow and Lakes (2014) | It is a case study regarding policy and land-use (i.e., land use displacement) of the Brazilian soybean sector, arguing that decoupling has taken place after the policy implementation. | Case Study | Brazil | No |
| 20 | Gryson et al. (2009) | By discussing the strategies for GM and non-GM soy from import to processing, this study shows that many tools are in place to ensure and maintain the current coexistence. However, a profound harmonization of procedures and methods at a European level should be encouraged. | Case Study | No | No |
| 21 | He et al. (2019) | This study explored how trade barriers increase global environmental costs of agricultural production, arguing that a sustainable cropping system in the global market would improve the environmental performance of the global agricultural system. | Modelling | China and United States | No |
| 22 | Heron et al. (2018) | This study takes soybean value chain governance as a case to argue that sustainability is difficult to foster by considering the peculiar structural and institutional characteristics of the soybean. | Case Study | No | Governance Theory |
| 23 | Hospes (2014) | This study investigated the effectiveness of RTRS and RSPO, concluding that the global stakeholder governance initiatives can be used to fill governance deficit. However, to better implement, national standards need to be launched. | Case Study | Brazil and Indonesia | No |
| 24 | Ingram et al. (2018) | This article is a case study regarding the effectiveness of landscape governance in soy, tropical timber and palm and oil value chains. Finally, it concluded that chains sourced in tropical landscapes may be governed more effectively for sustainability if voluntary, market policy tools and governance arrangements have more integrated goals that take account of sourcing landscapes and impacts along the entire value chain. | Case Study | No | No |

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| 25 | Kamali et al. (2017) | The study discussed the evaluation of the economic, environmental and social performance of the soybean farming system in southern Brazil, showing that accounting for variability in key system partners provides insights into the robustness of system performance as well as the prediction of outcomes. | Modelling | Brazil | No |
| 26 | Lambin et al. (2018) | By discussing the role of supply chain initiatives in reducing deforestation, this study found that the zero-deforestation initiatives by individual companies face difficulties to target the forms of deforestation (e.g., those associated with legal activities). | Case Study | No | No |
| 27 | Leguizamón (2016) | I argue that the push for technological innovation by large-scale agribusinesses, in articulation with financial sector involvement, is both an example of and are instrumental in the process of distancing and abstraction identified in the agro-food literature. This paper also highlights how, despite agribusiness efforts to 'displace' and 'disappear' nature, these processes are never fully accomplished. I thus reflect on the socio-ecological contradictions that arise from the processes of distancing and abstraction which accompany the financialization of the corporate food system under neoliberal globalization. | Case Study | Argentina | No |
| 28 | Liu et al. (2019) | This study explored the utilisation of fertiliser in China Shaanxi Province, arguing that the use of chemical fertiliser has threatened the environment and decreased agricultural efficiency. It requires financial and technical supports to improve farmers' willingness to adopt conservation tillage. In addition, the change in the Chinese diet structure is another way for sustainable production. | Case Study | China | No |
| 29 | Mattsson et al. 2000 | It is a case study focusing on land use in life cycle assessment of vegetable oil crops, which suggested that the indicators (i.e., soil erosion, soil organic matter, soil structure, soil pH, phosphorus and potassium status of the soil, and the impact on biodiversity) combining qualitative and quantitative information can be used for assessing soil fertility and biodiversity. | Case Study | No | No |
| 30 | McKay | This paper focused on the "land-grabbing" in Bolivia and suggested that the development model threatened | Case Study | Bolivia | No |

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| | (2018) | the livelihood of small-scale farmers and increased the nation's dependence on food import. | | | |
| 31 | Medina et al. (2017) | By analysing the curbing enthusiasm for Brazilian agribusiness, the study suggested that the current enthusiasm of the potential for sustainable agricultural development needs to be based on the assessment of specific dynamics, which can avoid false expectations, and promote standardised concepts and perceived intervention strategies. | Secondary Data Analysis | Brazil | No |
| 32 | Meijer (2015) | This study presented a case study to discuss the effectiveness of four supply chain initiatives. Of all influential factors, particularly the powerful position of a limited group of actors with high leverage over producers was found to lead to more ambitious standards with regard to deforestation and higher adoption of these standards. Other factors played a less pronounced role in explaining differences between the effectiveness of supply chain initiatives to reduce deforestation. For all initiatives, the (perceived) demand for low-deforestation products played an important role in the establishment of the initiative and the adoption of the standards, and for all initiatives, leakage can compromise the impacts on actual deforestation. | Case study | Brazil and Indonesia | No |
| 33 | Meyer and Miller (2015) | This study developed a case study focusing on Zero Deforestation Zones (ZDZ) and suggested that REDD+ could provide a framework for private sector actors to implement their zero-deforestation commitments with reduced transaction costs, increased environmental integrity, and aligned incentives with the public sector. Many of these actors are now using certification, roundtables, and moratoria successfully to reduce deforestation in their specific supply chains. These initiatives would occupy an important role in facilitating the implementation and efficient functioning of ZDZs. Private sector initiatives would also invaluable for improving sustainability and social issues at the farm-level, such as optimizing fertilizer use and eliminating slave labor. "Zero deforestation" would need to be defined for different regions, incorporating criteria from REDD+ and private stakeholder initiatives, through multiple stakeholder processes that include indigenous peoples, producers, companies, governments, and civil societies. | Case Study | Brazil and Indonesia | No |

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| 34 | Newton et al. (2013) | This study discussed the effectiveness of sustainable commodity chains in tropical forest and agricultural landscape. It is suggested that the roles of actors in making impacts on agricultural production are depending on their positions and influences in supply chains. | Secondary Data Analysis | Brazil | No |
| 35 | Oliveira (2016) | From the perspective of geopolitics in the Brazilian soybean sector, the author suggested that the current understandings of politics in the Brazilian soybean sector are not sufficient. Moreover, studies regarding "soy-dollars" and "grain-dollars" can be undertaken to reinforce the existing understandings of soy politics. | Case Study | Brazil | No |
| 36 | Oliveira and Schneider (2016) | This study demonstrates that the agribusiness actors who are gaining more control over the soy complex are doing so in part through flexing and that the ability to flex may ultimately determine the trajectory of global agro-industrial restructuring. | Case Study | Brazil and China | No |
| 37 | Phélinas et al. (2017) | This study analysed the social, economic, and environmental sustainability in Argentina's soybean sector. On one hand, the use of the GM soybean production technique increased the yield of soybean production. On the other, it also led to land-use conflict and other environmental issues, which provides implications for the local agricultural industry. | Survey | Argentina | No |
| 38 | Prudêncio da Silva et al. (2010) | The authors proposed models testing the environmental varieties of Brazilian soybean transportation, arguing that the region of origin needs to be considered to reduce pollution as they have different environmental impacts. | Modelling | Brazil | No |
| 39 | Reis and Leal | By proposing a deterministic mathematical model to support temporal and spatial decisions of the soybean chain, the author suggested that a stochastic model is needed in further studies. | Modelling | Brazil | No |

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| | (2015) | | | | |
| 40 | Safarzadeh and Rasti-Barzoki (2019) | The findings reveal the equilibrium pricing decisions for the supply-chain players to maximize their profits, besides the best energy policy and supply-chain structure for the efficient management of household energy consumption. More precisely, the first scenario with the Nash structure between the manufacturer and energy supplier has the most advantages and the least disadvantages than the other scenarios. Also, the manufacturer subsidy has the most performance in the discussed energy- efficiency program. Finally, the present study shows the significant effects of considering the energy rebound, innovation abilities of the manufacturer, and consumer behavior assumptions in the household energy problems. | Modelling | No | Game Theory |
| 41 | Safarzadeh and Rasti-Barzoki (2019) | The results indicate that considering energy rebound can close profit calculations to reality. Additionally, the tax deduction is a more effective policy than subsidy schemes to support the energy-efficient manufacturer in competition with similar manufacturers. However, subsidy policy provides better conditions for the government to control the energy consumption of the household sector using energy price reform. | Modelling | No | Game Theory |
| 42 | Safarzadeh and Rasti-Barzoki, 2018 | By investigating the modified lexicographic semi-order model the author suggested that the application of the model improves the quantitative and qualitative decision-making process. | Modelling | No | No |
| 43 | Safarzadeh et al. (2018) | This study proposed a heuristic scheduling method for the pipe-spool fabrication process and argued that comparing the results obtained from the proposed heuristic algorithm and IBM ILOG CPLEX software showed that it is better to use the software in small and medium test problems, but for large size problems, which are similar to the real-world problems, the proposed algorithm is suitable. In addition, the | Modelling | No | No |

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| | | computational results show that the presented lower bound has an acceptable distance to the exact optimal solution. | | | |
| 44 | Sauer (2018) | This article examines relations between the arrival and expansion of soybean plantations, particularly in post-2001, as part of regional agro-strategies that have perpetuated and deepened long-standing conflicts over land in the state of Pará. It also highlights the emergence of new territorial disputes, which have created additional obstacles, increasing the demand for land and rising land prices while impacting processes by which land and territorial rights are secured in the state of Pará. | Case Study | Brazil | No |
| 45 | Sauer (2018) | This article examined the relationship between the arrival and expansion of soybean plantations in the post-2001 era, which highlighted the environmental and social challenges caused by the land-use conflict in the State of Pará. | Case Study | Brazil | No |
| 46 | Schleifer (2017) | This study suggested that Brazil’s soy producers first backed but then opposed private sustainability regulation, whereas in the sugarcane sector the dynamic was exactly the opposite. Through in-depth analysis and cross-case comparison, this article reveals how changing transnational conditions were decisive in shaping these outcomes. Specifically, shifting end markets exposed the two sectors to different economic and regulatory pressures. | Case Study | Brazil | No |
| 47 | Schouten and Bitzer (2015) | This paper analysed the Southern and Northern standards of sustainable governance standards and concluded that the Southern standards have different audiences to gain legitimacy and rely on different sets of legitimacy sources comparing with Northern standards. | Case Study | No | Legitimacy Theory |
| 48 | Sinayi and Rasti-Bar | By discussing the game theoretic approach for pricing, greening and social welfare policies in supply chains, the study found that collaboration between the manufacturer and retailer leads to a cleaner and efficient production. Moreover, the retail price in the corporate model is not lower than the noncorporate model, and | Modelling | No | Game Theory |

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| | zoki (2018) | the price and the environment can be significantly influenced by the policies. | | | |
| 49 | Taherzadeh and Caro (2019) | Focusing on the drivers of water and land use conflict in international soybean trade, this paper suggested that drivers of excessive land and water consumption need to be explored by taking region, economic conditions and environmental criteria into account. | Modelling | No | No |
| 50 | Tomei and Upham (2009) | This paper has barely begun to establish the nature of what critical UK observers might define as a 'sustainable' biofuel supply from Argentina. It suggested that there is a vocal body of NGO opinion, perhaps epitomised by Biofuelwatch, expressing the view that production of biofuel for export is undesirable and tantamount to expropriation of the rural poor by powerful western corporates. | Case Study | Argentina | No |
| 51 | Tomei et al. (2010) | This study presents a case study regarding the production and certification of Argentinean soy-based biodiesel. It concludes that at present certification schemes are unlikely to be able to address either the institutional challenges associated with their implementation or the detrimental impacts of the additional demand generated by biofuels. | Case Study | Argentina | No |
| 52 | Torres et al. (2017) | In this paper, the authors indicate how China and Brazil, telecoupled by trade in soybeans, are depending on each other as they try to balance environmental and economic objectives. Brazil, as a sending system, has created pressures on its natural ecosystems, which have led to losses particularly in the Cerrado biome and its ecotones in the Amazon's tropical moist forest biome. China, as a receiving system, has created a land asset important to regenerating its lost natural systems (e.g., forest cover areas). Both countries have different property rights regimes, which have created distinct circumstances in which they are to protect or regenerate their natural ecosystems. | Case Study | Brazil and China | No |

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| 53 | van der Ven et al. (2018) | This work provides a case study of non-state market-driven (NSMD) governance in soy, palm oil and cocoa sectors. The result suggested that a lack of broad market uptake limits the effectiveness of NSMD. | Case Study | Brazil, Côte d'Ivoire, Indonesia and | No |
| 54 | Virah-Sawmy et al. (2019) | In this study, the results show that companies along the soy–meat value chain have made different sustainability commitments probably because they are facing very different risk factors: those upstream such as soy traders are concerned mainly with international pressures associated with deforestation, whilst those further downstream in the supply chain have from very loose to very ambitious sustainability objectives on various topics associated with the sector including animal welfare, climate change and human health. We found that these supply chain initiatives are not addressing sufficiently the cause and effect of key drivers of sectoral impacts such as land appreciation and the global demand for cheap meat. Further, because the soy–meat sector is vertically integrated both upstream and downstream, this may result in comparable bargaining power among business actors such that none of these actors may be able to impose sustainability norms without inferring cost onto themselves or causing perverse outcomes. | Case Study | Brazil | No |
| 55 | Waldman and Kerr (2014) | This study explored the ways in which supply chain initiatives and standards used to change practices in soybean and corn production. The conclusion is that certification schemes and standards face challenges to reduce and limit environmental pollution. | Case Study | No | No |