TRADE, DEVELOPMENT &
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The Social Impacts of Soy Production

A Systematic Review

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Executive Summary

International trade in soybean has been increasing exponentially over the last 30 years stimulating agricultural expansion and intensification in South American countries such as Brazil, Paraguay and Argentina with the purpose to increase the global supply but also to boost economic growth and development. Trade in soybean has been promoted by national countries and international agencies to stimulate economic development in low- and middle-income countries. GDP and average income in producing countries seem to have benefit from trade liberalization but they also experienced environmental and social costs. Soybean production in fact is also linked to extensive deforestation and clearance of natural vegetation as well as land grabbing phenomenon and social conflicts among communities in soy production area. Such costs and disadvantages of international trade are often less visible compared to the economic benefits and by recognising and measuring negative impacts together with the positive one is needed to implement and improve policies and interventions for sustainable trade.

This report, as part of UKRI GCRF TRADE Hub's work on the impact of global agricultural trade on people, presents a systematic literature review of the direct and indirect social impacts of soybean agricultural production for trade. The report employs the concept of multi-dimensional well-being to classify the various direct social impacts that have been found in the literature and the concept of ecosystem services to classify the indirect social impacts, i.e., contribution to well-being of natural ecosystems.

The main findings of the review are:

1. The empirical evidence relative to direct social impacts is scarce and mixed in terms of direction of impact. More tangible dimensions such as income, nutrition and living standards seem to be positively impacted by trade while more intangible dimensions such as freedom of choice and cultural value are found to be negatively affected by trade.
2. The empirical evidence relative to indirect social impacts, i.e., impact on ecosystem services, is more comprehensive and show a clear picture of negative impacts associated with soybean production due both to land use changes and loss of highly natural areas, e.g. deforestation, and agricultural intensification, e.g. pesticide applications and mechanised tillage.
3. The role of value chain policies for mitigating negative social impacts of soybean production has almost never examined by the literature reviewed. The value chain initiatives for sustainable governance of soybean production and trade are mainly focused on mitigating environmental impacts but also the evidence of the impact of such policies on indirect impacts, i.e., ecosystem services, is very limited.

Further research on identifying how different dimensions of well-being are impacted by soybean production is needed, especially to understand what are the trade-offs among well-being dimensions of an economic development model based on international trade. Further research is also needed to understand the link between environmental impacts and consequences for human well-being and actually quantify the loss of ecosystem service benefits due to environmental impacts.

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Figures and Tables

Introduction and background

Agricultural expansion and intensification as a development strategy for low- and middle-income countries has been promoted greatly by international development agencies as well as national governments in the past 30 years (World Bank, 2019). For these countries, liberalization of international trade in agricultural commodities is expected to attract investments and stimulate economic growth by increasing productivity and efficiency of the agricultural sector as well as all other economic sectors involved in production for export. At global level, the impact of international trade and the increase in volume of international traded commodities is found to be linked to an increase in average income and reduction in the poverty rate in many countries. However, these positive benefits associated with trade may be overestimated if the impact of such economic growth at different scales is not taken into account, e.g. at local and individual level, and there are environmental and social costs that arise because of agricultural expansion and the intensification due to trade.

The production of soybean for trade is an example of the complexity of impacts that liberalization of international trade may generate in producing countries. Soybean production is mainly realised in South American countries such as Argentina, Paraguay and Brazil (De Maria et al., 2020), characterised by the availability of vast area of land suitable for agriculture, but is expected to increase also in African countries to support the development of the biodiesel industry/sector (Drabik et al., 2016; German et al., 2011). The development of the soybean sector, and more broadly the agricultural sector, in Brazil in the last 30 years has demonstrated the positive effects of international trade on economic growth in terms of an increase of average incomes and a reduction in the number of people under the poverty line as well as a general increase in consumption expenditure (Fearnside, 2001; Garrett and Rausch, 2016; Weinhold et al., 2013). However, such developments have come at the cost of deforestation and clearance of natural vegetation, due to the need to clear land for expanding agricultural areas, and environmental degradation, due to the intensification of agricultural practices (Sauer, 2018). Moreover, the liberalization of trade has also raised concerns around a wide range of negative social impacts, such as violent land grabbing phenomena and farmers displacement, as well as violations of human and labour rights (Busscher et al., 2020; Greenpeace Brazil, 2018).

The environmental impacts, especially those associated with the deforestation of the Amazon, have been recognised and acted upon through various value chain initiatives that involves national governments, international organizations and private sector businesses, such as agribusiness companies and international traders (Virah-Sawmy et al., 2019). For example, the Soy Moratorium is a voluntary agreement that involves large transnational grain companies such as Cargill, Bunge and Amaggi, soy producers and environmental NGOs which ban the direct conversion of the Amazon forests for soy production. Other examples of value chain initiatives that aim to mitigate both negative and positive environmental impacts include certifications, for example those promoted by the Round Table for Responsible Soy (RTRS), as well as social corporate responsibility policies of individual businesses involved in trade. The certification promoted by the RTRS for instance promotes a set of principles and standards relative to five main broad areas that covers both issues relative to environment, environment responsibility principles, and to people, responsible labour conditions and responsible community relations principles.

The value chain governance initiatives as well as private business social corporate responsibility policies focus mainly on specific aspects of negative impacts on people due to agricultural production and trade in agricultural commodities. These impacts are mainly relative to working conditions for plantations workers (e.g. RTRS – guidance principle 2), issues of land rights conflicts and land grabs (e.g. RTRS – guidance principle 3.2) and issues more broadly related to relationships with communities where businesses operate (e.g. RTRS – guidance principle 3.4). However, broader social impacts associated with agricultural expansion and intensification such as the possible consequences on different stakeholder and residents in a soybean production area or whether the economic gains produced by trade in soybean translates in an equal increase in incomes for all the population are often under-researched (Russo Lopes et al., 2021).

In this report we undertake a systematic review to identify the social impacts associated with agricultural production of soybean with a focus on impacts in producing countries. We focus on all impacts that are empirically measured and that can be related to the concept of multidimensional well-being and we also aim to assess whether value chain initiatives and interventions have a role in mitigating social impacts of soybean production. Moreover, to assess the sustainability of soybean production we map the results of our review to Sustainable Development Goals (SDGs).

Methodology

We performed a systematic literature review with the aim to understand the socio-economic impacts associated with soybean agricultural production and expansion for international trade in the producing countries. The literature review was conducted with the aim of answering the following research questions:

1) What tools and metrics are used to assess the impacts of soybean agricultural production and expansion on population's well-being and ecosystem service supply?
2) What are the impacts of soybean agricultural production and expansion on the population well-being (direct impacts)?
3) How do these impacts differ across groups of people and across different actors?
4) What are the impacts of soybean agricultural production and expansion on the supply of ecosystem services and the benefits enjoyed by the human population (indirect impacts)?
5) What are the main drivers of change of direct and indirect impacts?
6) What are the effects of policy and non-government interventions on direct and indirect impacts associated with soybean agricultural production and expansion?

Search strategy

The focus of the literature review is on empirical studies measuring direct and indirect impacts of soybean agricultural production with a global focus, i.e., including all producing countries. The review included two main sources of literature: peer-review literature and grey literature produced by key trade-related organizations. The review for direct impacts has been conducted separately from the review of indirect impacts and the results will be presented separately but the protocol employed, except for the search terms used, is the same for both searches.

Peer-review literature

ISI Web of Knowledge's database is selected as the (only) search engine and database to conduct a comprehensive search of the peer-reviewed literature.

For the review on direct impacts, we developed an initial list of search terms by reviewing the terms used in comparable systematic literature reviews on well-being/poverty topics, for instance Roe et al. (2013). The search was refined iteratively through filtering by disciplines, document type (article) and publication years (2000-2020) to gain an applicable and manageable number of hits. The search terms presented in Table 1 generated an initial number of hits of 19,625 reduced to 6,825 for the first abstract screening.

Table 1: Search terms – well-being

Well-being/MPI		Product
"wellbeing" OR "well-being" OR "well being" OR "income" OR "poverty" OR "human well*" OR "nutrition" OR "livelihood*" OR "security" OR "vulnerab*" OR "(social) capital" OR "human capital" OR "asset*" OR "social welfare" OR "social impact" OR "economic impact" OR "welfare" OR "poor" OR "quality of life" OR "well living" OR "living standard*" OR "utility" OR "life satisfaction" OR "prosperity" OR "progress" OR "needs fulfillment" OR "development" OR "empowerment" OR "capabilit*" OR "poverty" OR "happiness" OR "deprivation*" OR "educat*" OR "mortality" OR "wealth*" OR "marginalis*" OR "disadvantage*" OR "*equity" OR "*equal*"	AND	"soy*"

Similarly, for the literature review relative to the indirect impacts an initial list of search terms was developed by reviewing the terms used in comparable systematic literature reviews on ecosystem services, for instance Harrison et al. (2014). The search was refined iteratively through filtering by disciplines, document type (article) and publication years (2000-2020) to gain an applicable and manageable number of hits. The search terms presented in Table 2 generated an initial number of hits of 34,254 reduced to 1,042 for the first abstract screening.

Table 2: Search terms – ecosystem services

Ecosystem services		Product
"Ecosystem service*" OR "Ecological services" OR "environmental good*" OR "environmental service*" OR "Provisioning service*" OR "Food production" OR "Food suppl*" OR "Foodcrop*" OR "Timber production" OR "Timber suppl*" OR "Timber" OR "Fuel production" OR "Fuel suppl*" OR "*Wood production" OR "*Wood suppl*" OR "Charcoal" OR "Fuelwood" OR "Firewood" OR "Wood" OR "Ntfp" OR "Non*timber forest product*" OR "Nwfp" OR "Non*wood forest product*" OR "*Water provision" OR "*Water suppl*" OR "Regulating service*" OR "Water purification" OR "Water quality" OR "Water regulation" OR "Water quality regulation" OR "Nutrient* retention" OR "Water quantity regulation" OR "Waste treatment" OR "Clean Water" OR "Flood protection" OR "Flood defence" OR "Flood storage" OR "Flood attenuation" OR "Climat* regulation" OR "Carbon storage" OR "Carbon sequest*" OR "Carbon loss" OR "Carbon emi*" OR "Erosion protection" OR "Soil fertility" OR "Soil erosion" OR "Disease regulation" OR "*Pest control" OR "Biological control" OR "Pollination" OR "Storm protection" OR "Natural hazard regulation" OR "Moderation of extreme events" OR "Cultural services" OR "Tourism" OR "Recreation" OR "*Aesthetic*" OR "Sense of place" OR "Heritage" OR "Spiritual"	AND	"soy*"

Grey literature

The strategy for the grey literature search involved using e-libraries and online repositories of key organizations selected from lists that have been developed by comparable systematic literature reviews on well-being/poverty topics, for instance Bottrill et al. 2014 (https://environmentalevidencejournal.biomedcentral.com/articles/10.1186/2047-2382-3-16/tables/2), and the SSRN repository (https://papers.ssrn.com/sol3/DisplayAbstractSearch.cfm). Moreover, we searched grey literature across soy sector specific sources such as private sector actors, certification bodies, sector-wide multi-stakeholder bodies and NGOs, non-academic research institutes (Table 3). The search of these repositories generated a total number of reports of 3,603.

Table 3: List of organizations used for grey literature search

International organizations	NGOs
Biodiversity international	WWF
CGIAR	Greenpeace
CIFOR	Solidaridad
FAO	Oxfam international
IIED	InterAction
IMF	ActionAid international
IUCN	ActionAid UK
UNEP	Concern worldwide
WorldBank	Consumers international
UNCTAD	Mercy corps
AidData	**Non-academic institutes**
Care International	IDH - trade initiative
Conservation Evidence	IISD
UNEP-WCMC	International trade centre
UNDP	Chain reaction research

Sector-wide bodies	Certification bodies
Round table for responsible soy	UTZ
ProTerra	FairTrade
World Business council for sustainable development	Rainforest Alliance
Consumer good forum	UN Global compact
Abiove (brazilian association of vegetable oil industries)	

Private sector actors	
Producers	**Traders**
AGD	ADM
Adecoagro SA	Atagi
Amaggi	Bunge
Cresud SA	Cargill
Grupo SLC agricola	Cofco

Inclusion and exclusion criteria

The literature has been screened using two sequential screening processes. The first step regards screening the article title and the abstract while the second step regards screening the article content. The exclusion and inclusion criteria used for the first screening process (abstract and title) differ across academic and grey literature while the criteria for the second screening (article/report content) are the same across the two type of literature.

Peer-reviewed academic literature – first screening

The criteria applied for the first screening (title and abstract):

- Inclusion: Empirical studies that use primary data or present a new analysis of existing secondary data, quantitative and qualitative, based in one or more countries, and that measure some form of poverty/well-being/resilience etc. at country, sub-national, household and/or individual level, focusing on soy production.
- Exclusion: As well as opposites on the above, studies using mechanistic models, scenarios or attitudinal reviews without providing new empirical data or new analysis of secondary data sources for links between soy production and well-being/poverty; existing reviews or meta-analyses; inaccessible papers; non-English papers.

No studies are excluded based upon quality. We assumed that the academic publishing process provides a sufficiently rigorous assessment, and we acknowledged that ideas of what constitutes quality are not homogeneous.

Grey literature – first screening

The grey literature selection included only reports as a document type (and excluded documents such as policy briefs). To screen the grey literature, we used a three sequential screening process. First, we screened the article title, then the abstract and next the article content.

The title criteria involved:

- Inclusion: Titles must mention the relevant product (i.e. soy).
- Exclusion: Titles which suggest that the study focuses on chemical or genetic analysis or suggest that the report does not provide an analysis of primary or secondary data (but rather, a review or meta-analysis).

The criteria applied to the abstracts are the same as for the peer-review academic studies.

Second screening

The criteria for the content screening are largely the same as for the title and abstract screening. The reasons for exclusion in the second screening are likely to concern not being empirical, no mention of any link of soy to human well-being and article inaccessibility.

After these steps (Figure 1), 18 articles about well-being impacts and 16 articles about ecosystem services impacts remained for the analysis. There is no grey literature that has been included in the literature dataset.

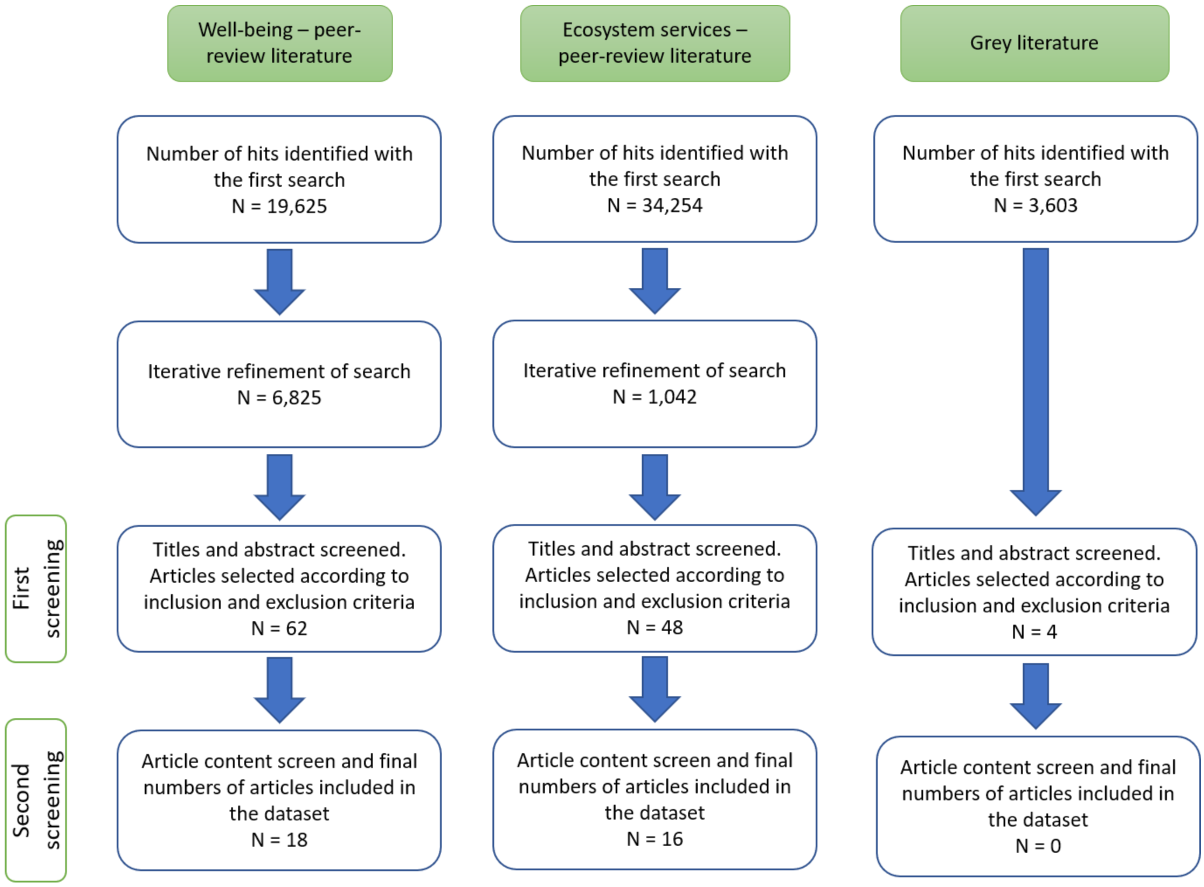

Figure 1: Systematic review process

Literature dataset and coding scheme

The articles selected after the second screening have been included in a literature dataset by first extracting all relevant information using an online survey tool (google form) and next by coding that information in a standardised way such that the literature included can be examined through quantitative methods.

Impacts on well-being (direct impacts)

To classify the direct impacts of soybean agricultural production and expansion reported in the literature we employed a multidimensional concept of well-being (Watts et al. 2019, Schleicher et al., 2018, Schaafsma et al. 2021 FRAMEWORK PAPER) which includes 9 different well-being dimensions classified as outcomes, and 3 well-being dimensions classified as outputs (Table 4).

Table 4: Classification of well-being impacts

Well-being dimension - outcomes	Description
Health (physical)	Feeling strong and well; able bodied; and your ability to maintain your health
Food/Nutrition	The ability to provide in your personal and your households food and nutritional needs throughout the year, including food that you buy, produce yourself or collect in the area in and around your village.
Education	The ability to obtain the schooling you want personally, to send your children to school, including the required materials (e.g. books, uniforms, materials, fees)
Living standards	Shelter (adequate flooring, roofing and walls, sanitation, electricity); motorbikes or bicycles; mobile phones; farming/fishing equipment; livestock; safe drinking water; fuel.
Cultural value	Your freedom to conduct traditional, cultural, tribal and religious practices, and spiritual values, including those attached to nature.
Freedom of choice and actions	Your ability to live the life you want, with a sense of power to control and agency over your own life; according to your values and norms; being independent from the goodwill of others; including your livelihood such as a self-sustaining farmer/fisherman; the ability to choose and achieve your goals in life; and your ability to influence decisions that are made by others in your community and beyond that affect your life; to be empowered; a life without discrimination (race, gender, etc.)
Security, safety from other people (Sense of security)	Safety and confidence in the future; peace and harmony – free from harm inflicted by other people, such crime, mugging, physical violence (incl. rape), lack of protection from police, lack of justice.
Living in safety from risk inflicted by nature, and in a clean, healthy environment (Environmental risk)	Extensive harm or psychological stress created by exposure to environmental risk Your ability to feel that your life is safe from droughts, floods, heatwaves, mudslides, storms, tsunamis, earthquakes, etc. Your ability to live surrounded by clean water in rivers and lakes, breathe clean air, i.e. live in a safe and healthy environment free from pollution Your ability to live without suffering crop losses, killings (by elephants, hippos, lions, etc.)
Social relations	Your ability to have meaningful relationships with your family and friends, to have family cohesion and respect within families, communities and external actors, your ability to help or rely on others in times of need. This includes for example your ability to care for, raise, marry and settle children, and to participate fully in society and social events such as celebrations, weddings and festivities.

Well-being dimension - outputs	Description
Income/expenditure	change in income or expenditures expressed it in monetary terms
Human Development Index (HDI)	a combination of income, education and health dimensions
Sustainable livelihood framework (SLF)	impact measured through scoring over different assets under SLF framework

For each article or report, we recorded as a single impact every empirical measure of change in the well-being dimensions described above that is associated with soybean production. In addition, we collected information regarding methods, including indicators used and qualitative themes explored, geographical location and scale of analysis of the study, sampling strategy and type of actors involved in the study, as well as the direction of impact for each of these actors when heterogeneous impacts for different actors are reported.

Impacts on ecosystem services (indirect impacts)

Agricultural expansion and intensification due to international soybean trade may also have indirect impact on people through impacts on natural ecosystems, such as forest, and influence the ability of the natural ecosystems to provide goods and services that contributes to human well-being, i.e., ecosystem services (ES). Ecosystem services are defined by the UK National Ecosystem Assessment as "*The benefits provided by the ecosystems that contribute to making human life both possible and worth living*" (UK NEA, 2011). The linkages between the ecological and the socio-economic system are exemplified in the cascade model shown in Figure 2. The capacity to provide ES depends on the environmental structure of an ecosystem and its underlying ecological processes, such capacity is often called the potential ES flow or ES supply (Vallecillo et al., 2019). The potential flow becomes an actual ES if there is a population that benefits from it and hold values for it (Potschin and Haines-Young, 2011). Measuring indirect impacts requires identifying the ecological process/structure that provides such service, i.e. the stock of natural capital, quantifying the potential service supplied and assessing how much of the potential service is actually captured by the population (Balmford et al., 2011).

Combining these impact measurements requires the contribution of many disciplines and during this systematic review we often found that articles report a measure of just one element of the cascade model, e.g., properties of the stock of natural capital or % of contribution to GDP due to crop yields. In the following we will refer to *environmental impacts* when a study evaluates properties of the natural ecosystem, i.e., the stock of natural capital that generates the flow of ecosystem services, and to *ecosystem services impacts* when a study identifies the actual or potential impacts on people. In the conceptual framework, ES are considered as outputs that provide the means to reach a well-being outcome.

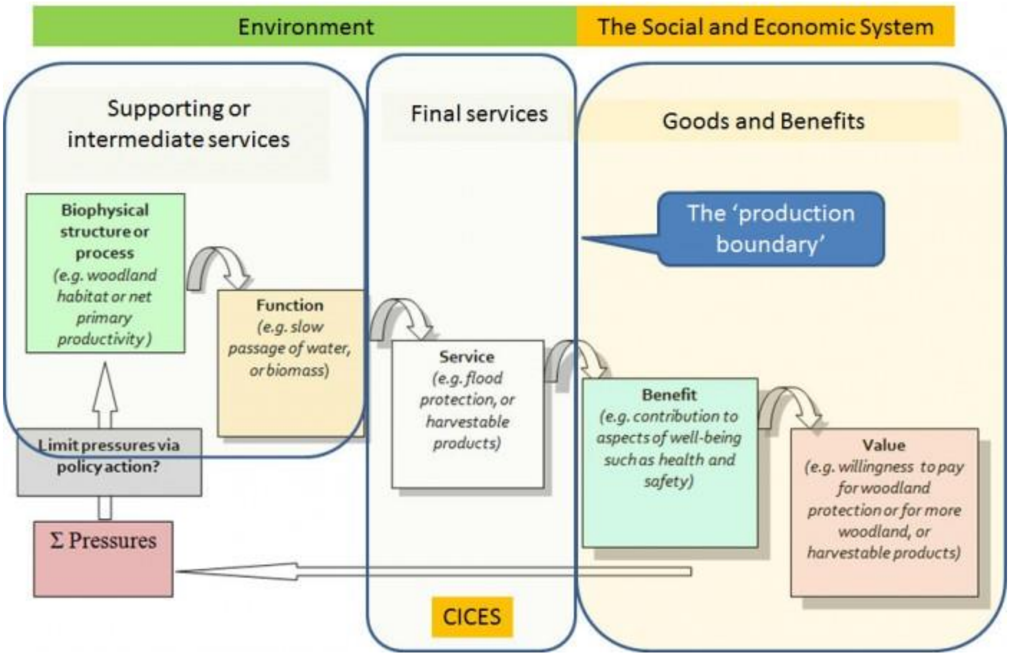

Figure 2: ES cascade model (Potschin and Haines-Young, 2011)

To classify the environmental and indirect impacts of soybean production, we used the classification of The Economics of Ecosystems and Biodiversity (TEEB, 2010) and included provisioning, regulating and cultural services (Table 5).

Table 5: Classification of ecosystem services

Provisioning services
Food provision
Wild food provision
Raw materials
Water provision
Genetic resources
Medicinal resources
Ornamental resources
Regulating services
Air quality regulation
Climate regulation
Hazard protection
Water quantity control/regulation
Water quality regulation
Erosion prevention
Maintenance of soil fertility
Pollination
Pest control
Cultural services
Aesthetic experience
Recreation and tourism
Inspiration for culture
Spiritual experiences and cultural identity
Education
Existence - bequest values

The sample of our studies is composed of a very heterogeneous set of environmental and ES impacts associated with soy production. To make the direction of impact comparable across our dataset entries, we used specific rules that considered how the impacts were measured. The two main research designs employed by the screened articles measure the impact of agricultural production through comparing the change in environmental properties or ES provision of different agricultural practices either in the same cropland areas or in different ecosystems, e.g., forest and cropland. Specifically, if a study examined the impact of agricultural practices, we considered as the benchmark for the comparison the intensive agricultural practices, e.g., monoculture practices with mechanised tillage and fertilizer and pesticides application, and we recorded impacts as positive (negative) if the alternative agricultural practices increase (reduce) the provision of ES or improve (worsen) environmental conditions compared to the benchmark practices. For studies that compares different ecosystems, we consider as the benchmark the cropland ecosystem and we recorded impacts as positive (negative) if the ecosystem that has been compared to cropland provides more (less) ES or its ecological structure and functioning is (less) more ‘resilient’, ‘healthy’ or ‘diverse’.

Results

In the following we present the results for the well-being and ES impacts separately. Three studies that have been included in the well-being impacts dataset also report impacts on ES benefits, so the final total number of papers included in the indirect impacts' dataset is 19.

Direct impacts of soy production on well-being

Descriptive statistics of the sample

The direct impact dataset is composed of a total of 18 papers for which 44 different impacts on well-being have been recorded. There are 6 papers that include multiple measures of well-being associated with different dimensions. The total number of papers using individual level data is 12 for a total of 31 impacts recorded while the total number of papers using population level data is 6. Most of the articles regard soybean production in America, both North and South America, and about 85% of the impacts regard just three countries (Paraguay, Argentina and Brazil).

Table 6: Overview of the article's dataset

Number of studies	18
Number of well-being impacts recorded	44
Number of studies using individual level data (primary data)	12

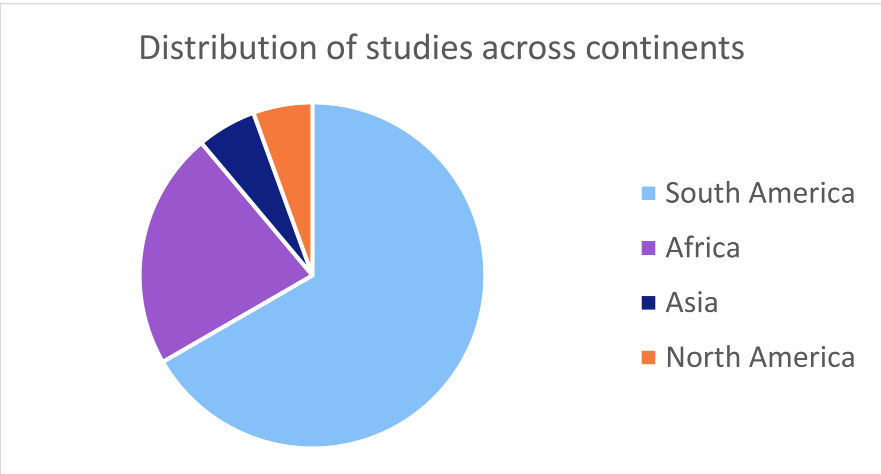

Figure 3: Distribution of studies across continents

Methods and metrics

Figure 4 shows the number of times that the impact of soybean production for each well-being dimension has been measured. Overall, we found evidence that the impact of soybean production and expansion for international trade on well-being is multidimensional, although some well-being dimensions have not been measured at all within the soybean literature, i.e., education and environmental risk. The dimension that is most measured is income, but if we exclude articles that conduct secondary data analysis, the number of times that the different well-being dimensions have been explored is about the same.

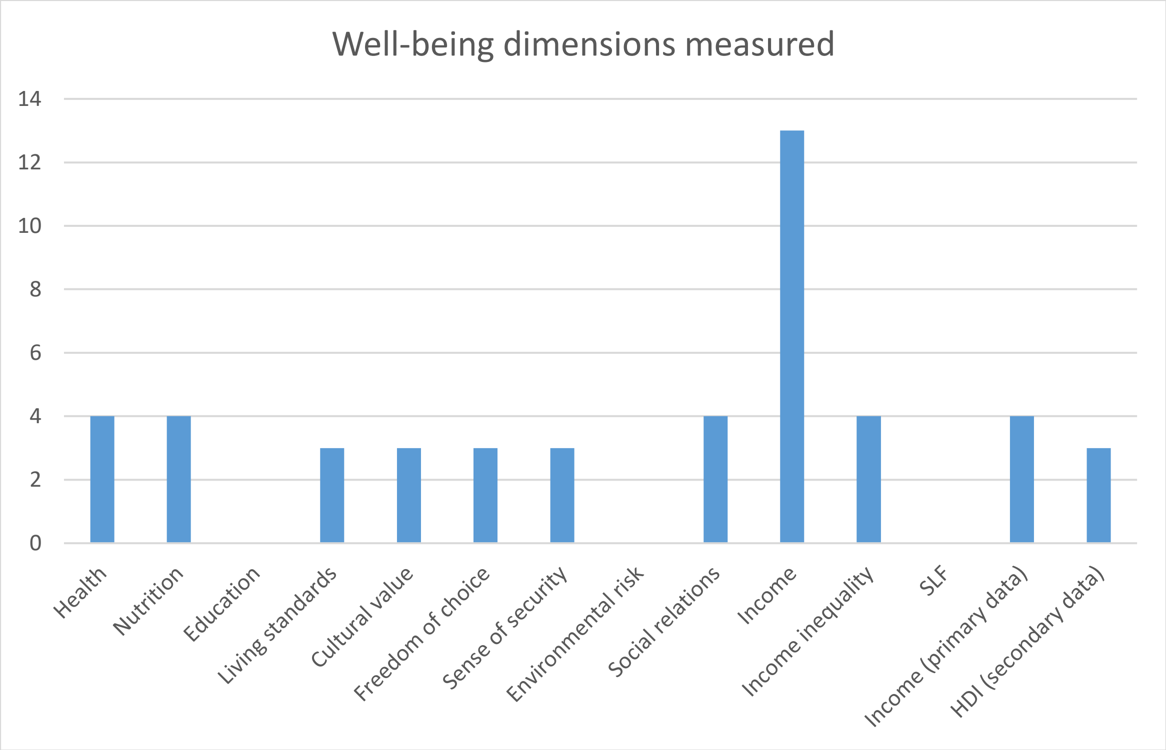

Figure 4: Counts of well-being dimensions measured

The set of impacts recorded in our dataset includes more tangible dimensions such as positive impacts on economic income due to rural economic development and economic growth (Choi and Kim, 2016; Krapovickas et al., 2016; Lima et al., 2011; Weinhold et al., 2013), negative impacts on human health because of occupational hazards and pollution of drinking water sources (Almberg et al., 2014; Bernieri et al., 2019; Ruder et al., 2009) and on nutrition and food security as a result of agricultural intensification and crop shifts promoted by international trade market incentives. We also found evidence that soybean production may have an effect on more intangible dimensions of well-being such as the cultural value of traditional agricultural practices and rural lifestyles (Auer et al., 2017; Krapovickas et al., 2016) and the sense of security and freedom of choice that depend on secure land tenure rights and access to development opportunities (Busscher et al., 2020; Krapovickas et al., 2016; Steward, 2007).

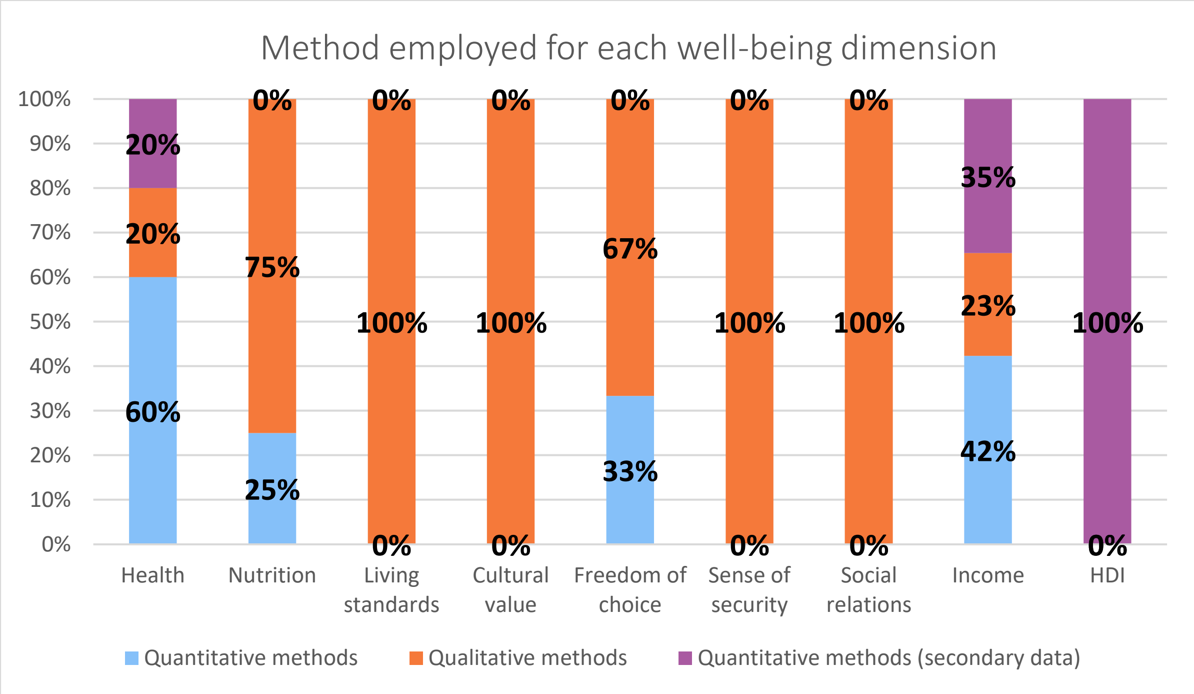

Figure 5: Type of method used in impact studies for each well-being dimension.

The primary data studies included in the dataset employ both qualitative and quantitative methods in a balanced way: 50% of the studies (6 papers) employ qualitative methods and the other half employ a quantitative method. Studies that employ qualitative methods report impacts for at least two different well-being dimensions and in total they measure about 80% of the impacts recorded from primary data studies. The studies employing quantitative methods focus mainly on measuring specific dimensions, as shown in Figure 5, such as health, nutrition, freedom of choice and income. Impacts measured through quantitative methods using secondary data (n=13) mainly focus on health and income dimensions. The most common indicators employed by studies using quantitative methods for each well-being dimension examined are presented in Table 7.

Table 7: Most common indicators used to measure social impacts of soybean production

Well-being dimension	Indicator
Health	Serum levels of thyroid function markers (FT4, TT3, TSH, BChE) Cancer risk indicator (odds ratio) Adverse birth indicators (low birth weight and preterm births)
Nutrition	Children's soybean consumption and children's dietary diversity
Freedom of choice	Composite indicator (gender empowerment)
HDI	Human development index Municipal Development Index
Income/expenditure	Crop yield*market price Willingness to pay (preferences for profitability) Business reporting (profitability) Income Poverty headcount Theil index Gini index

Direct impacts of soybean production

Negative impacts are recorded for half of our sample (22 out of 44) while positive impacts form about 30% of the reported impacts. Hence, the overall impact of soybean production on multidimensional well-being cannot be regarded as having a clear direction, either positive or negative. However, as shown in Figure 6, the majority of positive impacts recorded regard the income dimension, with fewer for nutrition and living standards (housing). On the other hand, negative impacts have been recorded across all well-being dimensions measured showing that there is a whole range of impacts associated with soybean production beyond the profit/economic dimension.

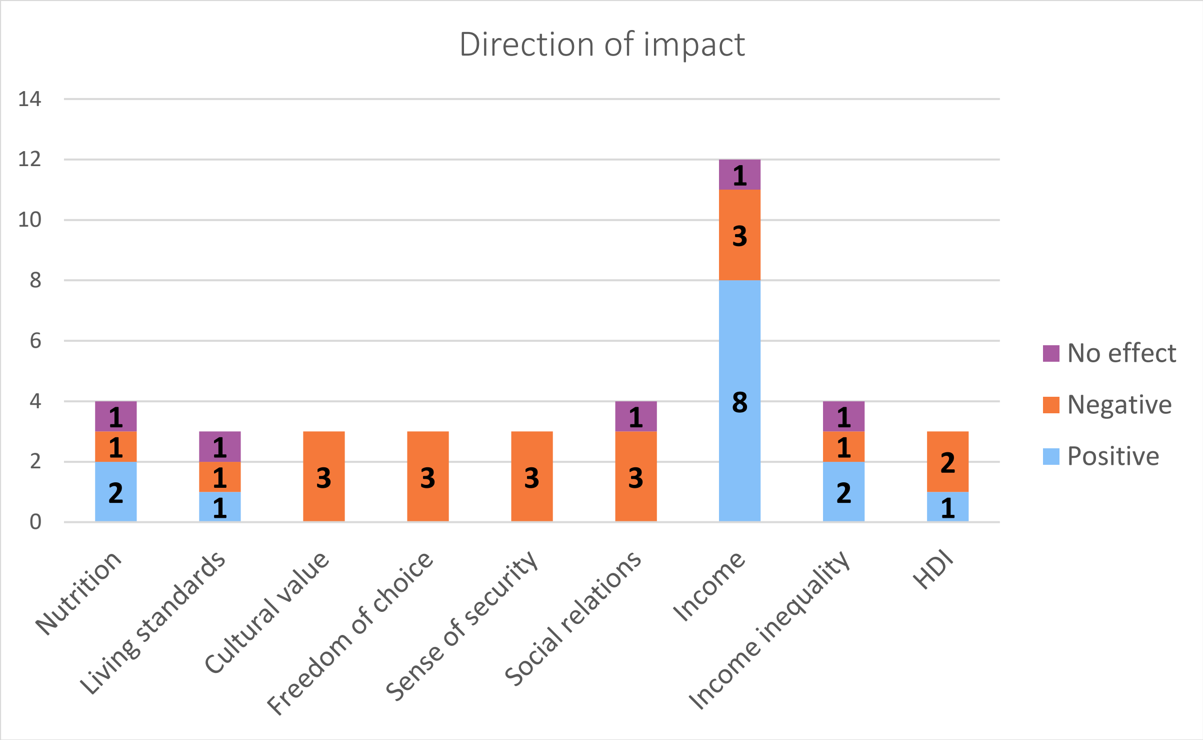

Figure 6: Direction of impact for each well-being dimension

We found evidence of a positive effect of soybean international trade on economic growth, measured by GDP, and a general improvement in economic conditions and development opportunities for farmers and rural inhabitants (Cardozo et al., 2016; Choi and Kim, 2016; Krapovickas et al., 2016; Lima et al., 2011; Martinelli et al., 2017; Sjauw-Koen-Fa et al., 2017; Weinhold et al., 2013). Martinelli et al. (2017) compared the human development index, a composite indicator that includes GDP per capita, education levels and general health status, between Brazilian municipalities with high prevalence of soy production and those with low presence and found that the indicator increased significantly more in the soy producing municipalities. Weinhold et al. (2013) explored the relationship between soy production and income dimension indicators such as changes in rural poverty rate, measured as the proportion of people below the poverty line, income inequality (Theil index), rural household median income and aggregate GDP in the 1990-2000 period in legal Amazon municipalities. They found that the introduction of soy production decreases rural poverty, and that the higher is the soy acreage, the higher is the positive effect on the poverty rate. However, they also found that the introduction of soy is associated with an increase in income inequality. Moreover, the relationship between soy-related variables and economic indicators is characterised by high spatial correlation which may indicate that the positive relationship between income and soy as well as the negative relationship with income (in-)equalities may differ across spatial areas. Choi et al. (2016) examined the regional disparities in the relationship between soy production and economic variables. They found that at aggregate level the increase of soy production in the period 1973-2013 was not associated with economic growth, measured by GDP, but it was associated with an increase in income inequality, measured by the Gini index, and an increase in the number of people under the poverty line. However, when they performed a geographically disaggregated analysis by comparing southern regions, characterised by small scale family farming, and northern regions, characterised by the presence of large-scale estates, they found that the relationship between the poverty headcount and soy is negative in the northern regions, while in the south an increase in soy production seems to have positive effect on the poverty headcount.

The economic benefits and the contribution of soybean trade to economic development have also been highlighted directly by the farmers and residents located in soybean agricultural expansion areas (Auer et al., 2017; Cardozo et al., 2016; Lima et al., 2011; Steward, 2007). However, these studies reveal how such development may come at the expense of intangible benefits, such as the cultural value attached to traditional agricultural systems (Auer et al., 2017; Krapovickas et al., 2016), or of alternative development opportunities (Cardozo et al., 2016; Lima et al., 2011) which may lead to displacement and migration (Lima et al., 2011) and to a general feeling of lack of freedom of choice (Busscher et al., 2020). Krapovickas et al. (2016) discuss the consequences of soy expansion for local populations and indigenous groups in Argentinian Chaco focusing on the pressures of agribusiness expansion on local common-pool resources, i.e. forest. The availability of forest resources has declined in the area due to deforestation, which seems to be led by agribusiness expansion, as well as privatization of communal forested land. By performing semi-structured interviews with local firewood users, the authors reveal that recent rural developments have decreased the availability of forest resources and as such limit alternative income opportunities as well as access to energy goods and more in general the freedom to practice a forest-based lifestyle, e.g., being free of sleeping into the forest. Auer et al. (2017) explored in detail, through semi-structured interviews with local people who had lived in the area for at least 20 years, the impact of agricultural intensification in Balcarce district (Argentina) and found evidence of negative impacts on cultural value and social relations component of multidimensional well-being. The authors found that traditional agricultural practices (for potato cropping) are associated with a sense of identity and belonging to a place and that the relative high presence of small-scale farmers in the past facilitated building good social relationships and an overall sense of community – which were lost with the intensification of soy production.

Some studies focus on understanding how impacts on multiple well-being dimensions vary across different social groups and stakeholders within the value chain (research question n. 3). Steward et al. (2007) interviewed different actors in the soy value chain in Brazil (Santarem area) and found that different stakeholders value benefits and costs of soybean expansion differently. The potential economic benefits of soy trade are strongly valued by local government officials as well as agribusiness actors, while NGOs members strongly emphasised the possible negative environmental effects (cf. section on indirect impacts). Local residents and smallholder farmers seem to be negatively affected by the increasing pressure to sell their lands and the lack of alternative development opportunities. On the contrary, Lima et al. (2011) also interviewed different local actors, soy farmers, non-soy farmers and soy labourers, influenced by the development of the soy value chain in different areas of Brazil. They found that respondents had an overall positive opinion of development brought by soybean and strongly valued the effect on income and improved housing and infrastructure. However, some of the respondents were also concerned about the negative impacts on water quality and the health risks associated with increasing use of agrochemicals. Bernieri et al. (2019) show that soybean agricultural practices in Brazil may pose a risk for the health of plantations labourers as, during their working time, they are exposed to thyroid-disrupting pesticides which can potentially determine long-term detrimental effects on their health. On the contrary, Ruder et al. (2009) looked at the relationship between exposure to pesticides among farmers in the US and risks of glioma and found that living on a farm on which soybean, and other crops such as corn, were cultivated was actually associated to decreased risk of glioma. Finally, Almberg et al. (2014) explored whether population locate in close proximity to pesticide-treated fields adverse health outcomes such as low birth weight or preterm births and found no effect on the association between corn, soybean or wheat crop density.

Indirect impacts of soy production on well-being (Ecosystem services)

Descriptive statistics of the sample

The dataset is composed of a total of 19 papers for which 40 different environmental and indirect impacts on people have been recorded. Most of the articles regard soybean production in America, both North and South America.

Table 8: Summary statistics of articles included in the dataset

Number of papers	19
Number of well-being impacts recorded	40

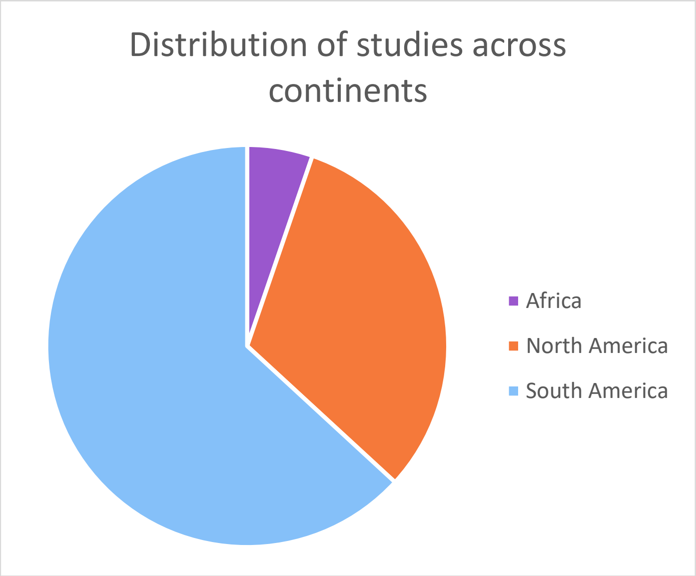

Figure 7: Distribution of studies across continents

Metrics and methods

Figure 8 shows the number of impacts associated with soybean agricultural production and expansion recorded for each ES using the TEEB classification. Regulating ES are the most studied (75% of the impacts) followed by provisioning ES (20% of the impacts). Specifically, the most studied regulating ES are climate regulation, water quality regulation and maintenance of soil fertility. The most studied provisioning ES is food provision supplied by the cropland ecosystem, but a few studies also measure impacts on wild food provision, raw materials, and water provision. The high prevalence of regulating services can be explained by the fact that the majority of the literature included in our dataset are environmental science studies which measure properties of the stock of natural capital, such as soil properties or abundance/scarcity of pollinators and agricultural pests. Table 8 shows the different methods that have been used to measure the ES impacts included in our dataset. ES research is highly interdisciplinary, and this is reflected in the wide range of methods that have been used.

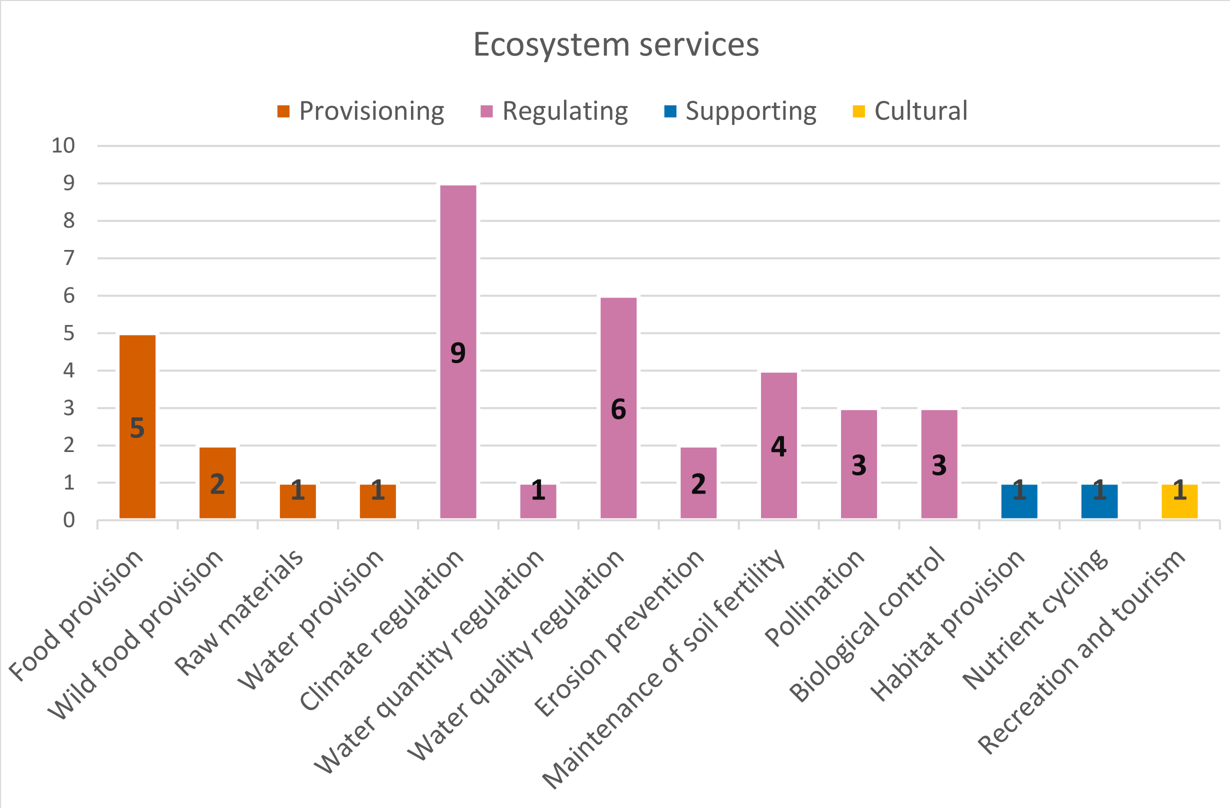

Figure 8: Ecosystem services type

43% of the studies uses environmental study measurements as a method to quantify ES supply; this category includes studies that performed primary data collection to measure properties and structure of the ecosystem and infer both the quality of the ecosystem processes and functioning and the potential ES production. An example of a study that uses environmental measurements is Paul et al. (2015) which empirically measure multiple soil properties, such as soil carbon content, bulk density, and soil aggregate fractions, at different soil depths to examine the impact of pesticide applications on soil fertility and formation. The study was complemented with a measure of crop yield across different agricultural practices treatment to evaluate the effectiveness of pesticide application on food provisioning services. Crop yield can be considered as an indicator of potential flow of ecosystem services as the crop yield can be consumed, either directly or as an input for human consumption products, by the human population and as such represents an ecosystem service benefit. Other ecosystem services such as pollination and biological control have been assessed mainly through environmental science primary data measurements (Koh et al., 2008; Mitchell et al., 2014; Monasterolo et al., 2015; Ruiz-Toledo et al., 2020). However, their actual contribution to human's well-being is very difficult to measure, as the effect on crop yield of underlying regulating services is influenced by a range of other factors. Therefore, studies that do not assess the relation to soy production are qualified as indicators of a healthy ecosystem structure which can contribute to provide benefits for humans.

About 35% of the studies employs a mixture of secondary data measuring environmental variables, either empirically measured or estimated through modelling, and information about interactions with human activities, e.g. agricultural practices. The combination of environmental modelled data with information on agricultural practices, such as the amount of fertilizer or pesticides used by farmers, permits to evaluate the impact on ecosystem services and the stock of natural capital considering the interaction between social and ecological system. In some cases, it is then possible to measure the actual flow of ES. Moreover, the use of modelled environmental and/or social data combined with empirical measurements allows to explore future scenarios of impact and draw inferences on best practices to mitigate current negative impacts. These analysis may be especially relevant for assessing the impact on water-related ecosystem services, such as water quality regulation and freshwater provision, where the magnitude of impact depends mainly on human practices, both in terms of water uses and water contamination. Maydana et al. (2020) assess both water quantity and quality regulations under alternative future modelled scenarios alternative management regimes (agribusiness vs conservation agriculture) while Darré et al. (2019) perform a similar analysis of current agricultural practices in Uruguay.

Table 9: Summary statistics of articles included in the dataset

Method	Count (%)
Benefit transfer	5%
Qualitative interviews	18%
Secondary data analysis	10%
Models coupled with farmers and expert information	25%
Environmental study measurements	43%

To measure the impact of human activities on the ecosystems, some studies use secondary data (10% of our studies), usually in the form of land use data, and employ proxies for ecosystem services provided by different land cover/uses (Baumann et al., 2017; Meehan and Gratton, 2016).

Finally, around 23% of the studies focus on measuring the actual flow of ecosystem services and the benefits enjoyed by the population either through qualitative interviews with farmers and other rural residents or by estimating the contribution of land cover/use categories to the country's economic wealth (e.g. GDP). Lima et al. (2011) explored the impact of agricultural intensification on water provision and soil properties through qualitative interviews with rural residents in areas characterised by recent agricultural expansion for soybean crop. Saraiva Farinha et al. (2019) monetize the recreational services provided by protected natural areas such as forests using benefit transfer.

To provide an indication of the high level of interdisciplinarity required to measure the impact of soybean production on ecosystem services, we show the set of unique indicators that have been used to measure impacts included in our dataset (Table 10).

Table 10: Most common indicators for measuring impact on ecosystem services of soybean

Ecosystem service	Indicator
Food provision	Crop yield per Ha
	Individual's perception
Wild food provision	Individual's perception
Raw materials	Individual's perception
Water provision	Blue water footprint
Climate regulation	GHG emission by land use category
	Monetary value for NPP (net primary production)
	Soil organic content (SOC)
	GHG emissions associated with insecticide use
Water quantity regulation	Water percolation
Water quality regulation	Individual's perception
	Ecotoxicity potential
	Soybean monoculture planted area
	Presence of agrochemical compounds (CY)
	Average base-flow NO3-N
	Nitrate leaching
Erosion prevention	Individual's perception
Maintenance of soil fertility	Crop residue in soybean fields
	Soil organic content (SOC)
Pollination	Abundance and diversity of native bee species
	Integrate pesticide index
	Bees abundance in soybean fields
Biological control	Relative insecticide use
	Natural enemy abundance
	Herbivore abundance, aphid abundance
Habitat provision	Species richness
Nutrient cycling	Nutrient concentration
Recreation and tourism	Benefit transfer

Impact of soybean production on ecosystem services

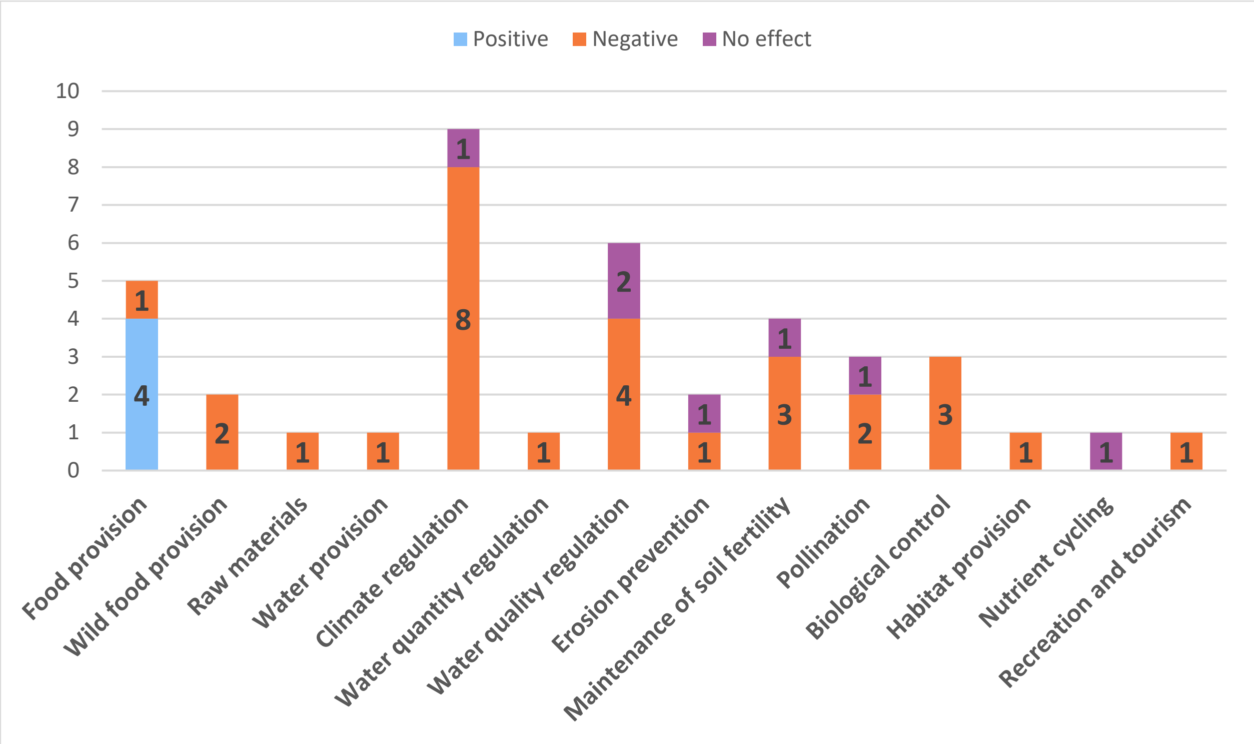

Figure 9: Direction of ecosystem service impacts

Overall, the number of positive impacts is small (10%) and only for one ecosystem service, food provision, while all the other ecosystem services seem to be negatively affected. The two main drivers of change in ecosystem service provision due to agricultural expansion for soybean production are land use changes, i.e., conversion of forest and other highly natural areas to cropland, and the intensification of agricultural practices (Figure 10). The agricultural practices are associated mainly with food provision, water quality regulation and soil-related ecosystem services, while land use changes (deforestation) are mainly associated with carbon sequestration.

Land use changes due to cropland expansion and impact on ecosystem service supply

Land use changes such as deforestation and clearance of other native vegetation, e.g. grassland and dryland savannah, have negative impacts on the supply of various ecosystem services such as climate regulation (Baumann et al., 2017; D'Acunto et al., 2014; Heimpel et al., 2013; Villarino et al., 2017), wild food provision and raw materials (Krapovickas et al., 2016; Malkamäki et al., 2016) as well as recreational and touristic opportunities offered by natural areas (Saraiva Farinha et al., 2019). Baumann et al. (2017) looks at deforestation patterns for the Chaco region, which includes Argentina, Bolivia and Paraguay, over a 30-year period and found that the Argentinian part of the region has been substantially deforested due to cropland and pasture expansion. The change in total carbon emissions associated with deforestation has been estimated by applying conversion factors from primary data studies to land use/cover types. The study found that over the period analysed there has been an increase in total carbon emission of 23% due to conversion of forests to cropland, mainly soybean fields, and of 71% due to conversion to pastures. A more detailed study from Villarino et al. (2017) focused exclusively on carbon stored in soil in the Chaco area using primary data to measure various soil properties at different depth levels. The study found that the carbon stored in soil declined due to deforestation and that soybean plantations are associated with a greater loss than other crops. The presence of permanent vegetated areas within cropland (uncropped margins) may mitigate the loss of carbon storage potential due to cropland conversion as demonstrated by D'Acunto et al. (2014). The study used primary data to measure the carbon stored into different fields with woody and herbaceous margins and found that the carbon storage capacity of soil of soybean fields differs depending on the distance from these vegetated margins: the soil within few meters from woody patches stores significantly more carbon.

Deforestation and conversion of other natural areas impacts also on ecosystem services that benefit mainly the population at local scale, by reducing the availability of raw materials, such as firewood and other energy goods, and wild food due to the lack of suitable habitat, as opposed to climate regulation which benefits the population at global scale in a more indirect way. Krapovickas et al. (2016) shows through qualitative interviews of rural residents in the Chaco area in Argentina how deforestation associated with soybean cropland and increasing restrictions on access to forest areas has limited the ability of the surrounding population to benefit from those natural areas. Forests and other natural areas also provide habitats for honeybees and support beekeepers honey production and beekeepers' income. Malkamaki et al. (2016) examines through semi-structured interview with beekeepers how land use changes due to cropland expansion in Uruguay has influenced honey yields. They found that soybean frontier expansion has had negative effects on honey production because soybean fields are characterised by very low amount of floral resources compared to other land cover/use types, e.g. grassland or eucalyptus plantations.

Bees together with other insects such as soybean aphids and arthropod herbivores and predators interact with the cropland ecosystem and contribute positively, e.g. pollination, or negatively, e.g. agricultural pests, to crop productivity (Dale and Polasky, 2007). Few studies, using primary environmental data, focused on understanding this relationship by examining the role of bees and other pollinators for soybean yield (Monasterolo et al., 2015) and how the landscape structure and the presence of highly natural areas such as forest or grasslands influences the prevalence of these insects in cropland areas (Koh and Holland, 2014; Mitchell et al., 2017; Ruiz-Toledo et al., 2020). Monasterolo (2015) examined the role of landscape fragmentation and the destruction of the insect's natural habitat, e.g. deforestation, in the Argentinian Chaco and found that the distance of cropland areas to forest influences the visitation rate of bees and that the soybean plant productivity is positively affected by the presence of bees, i.e. higher the visitation rate of bees higher the plant productivity indicators. Similarly, Ruiz-Toledo et al. (2020) examined the presence and diversity of native bees in a small-scale agriculture landscape in Mexico, where non-irrigated crops such as maize, soybean and sorghum are cultivated under a rotation regime, and compared areas fully converted to crops to areas where some more forest or other vegetated patch is still present. The study found no significant difference in the amount and diversity of bees indicating that land conversion in this case did not seem to negatively affect the pollination services. Forests and other semi-natural land uses provide a natural habitat also for natural enemies of agricultural pests, e.g. soybean aphids, which support crop productivity by reducing the number of pests and provide an alternative to the extensive uses of pesticides. Two studies (Koh and Holland, 2014; Mitchell et al., 2014) focused on cropland in North America (Canada and US) and found that the presence of forest and grassland increases the number of natural enemies of pests and therefore enhances the biological control services.

Finally, in Brazil the loss of the most natural and highly biodiverse areas such as the Amazon and the Cerrado due to the agricultural frontier expansion may also be detrimental for recreational and touristic activities. Mann et al. (2012) and Saraiva Farinha et al. (2019) estimated monetary values associated with the loss of natural areas, proxied by NPP and its estimated contribution to GDP, with the aim of providing a measure of potential losses due to agricultural development and compare those to potential profit gains from soybean plantations. They found that the value of forest and other natural areas is higher than potential economic gains from soybean.

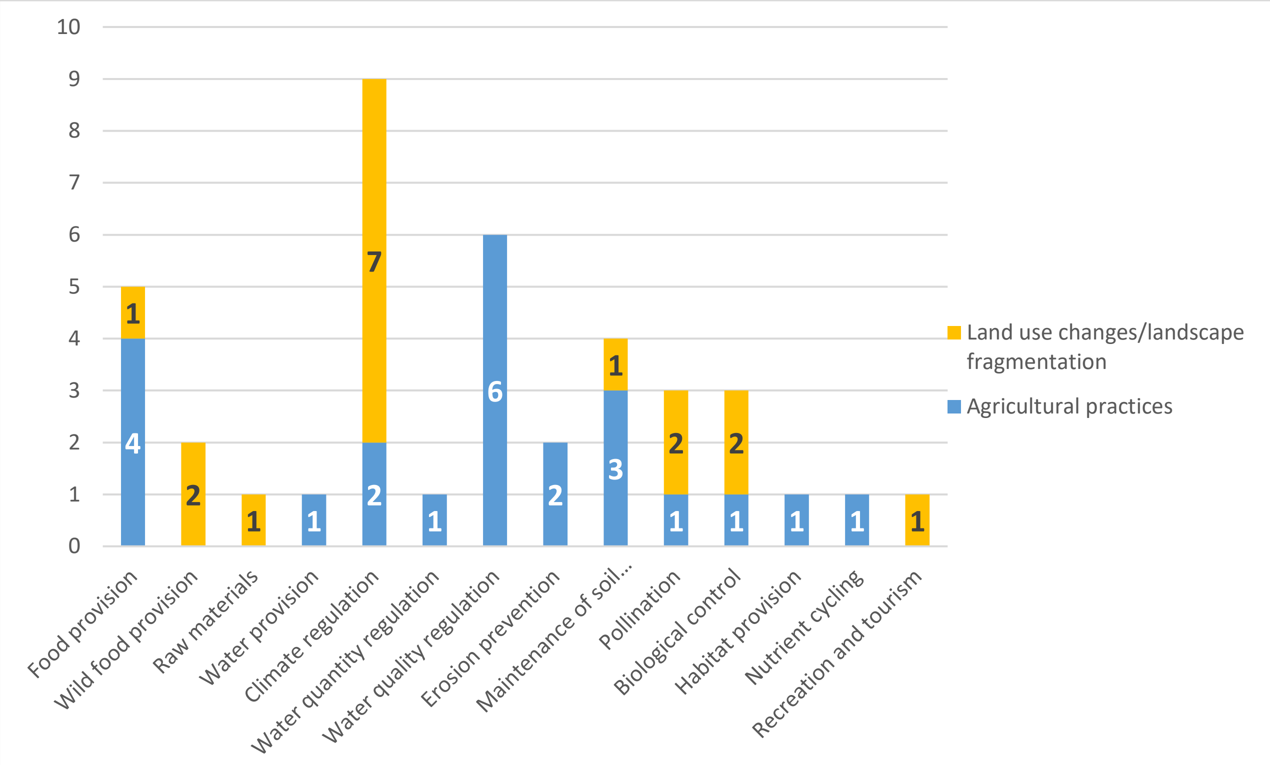

Figure 10: Drivers of change in ecosystem service provision

Soybean agricultural practices and impacts on ecosystem service supply

The agricultural practices employed in soybean production is the other driver that has been found to have an impact on ecosystem services supply; the literature has mainly focused on understanding the impact on water-regulating ecosystem services, both quality and quantity, as well as soil-related services and food provision service.

Water-related ecosystem services are influenced mainly by the intensification of agricultural production in soybean areas which causes both a relative increase in water consumption for irrigation uses as well as an increase of water pollution due to the use of pesticides and fertilizers (Darré et al., 2019; Lima et al., 2011; Maydana et al., 2020; Syswerda and Robertson, 2014; Villarini et al., 2016). Freshwater provision and water quantity regulation are affected by the increased water use that intensive soybean agriculture practices require, as opposed to rainfed or extensive agricultural systems (Darré et al., 2019; Maydana et al., 2020). Water quality regulation services are affected by the appliances of fertilizers, nitrate and phosphorous, and the use of pesticides. Nitrate and phosphorous leaching are well-known environmental impacts that are associated with intensive agricultural practices, which can lead to the disruption of the water ecosystems through eutrophication and therefore lead to further reduction of other ecosystem services such as freshwater provision (Darré et al., 2019; Maydana et al., 2020; Syswerda and Robertson, 2014). The use of pesticides also impacts the quality of the water and may have a more direct effect on the population's well-being by increasing the toxicity of water used for drinking or other domestic purposes and posing a risk for their health as discussed in the section about direct impacts. At the same time, the use of fertilizers and pesticides is also found to have a positive impact on food production as it increases crop yield (Darré et al., 2019; Mitchell et al., 2014; Paul et al., 2015; Syswerda and Robertson, 2014), indicating a trade-off between positive impact on food provision vs negative environmental consequences of intensive agricultural practices. As shown both by Maydana et al. (2020) and Syswerda and Robertson (2014), conservation agricultural practices, which may include avoiding tillage and limit the use of fertilizers as well as the use of organic pesticides characterised by lower toxicity, may help in mitigating these negative environmental impacts while still maintaining a high level of food production.

Intensive agricultural practices that involve mechanised tillage and the use of chemical compounds are also found to affect soil-related properties such as fertility and erosion and in turn may affect the productivity of the area over time and reduce food provision in the future. The maintenance of soil fertility is usually measured using environmental science primary data to evaluate the soil organic carbon content (SOC). It has been found that avoiding mechanised tillage strongly increases SOC while the use of pesticides does not seem to have an effect on soil properties (Paul et al., 2015).

Drivers of direct and indirect impacts and policy responses

The direct and indirect impacts associated with soybean agricultural production are mainly driven by the increasing international global demand for soybean products (De Maria et al., 2020) which generates pressures both on the natural and social system in soybean producing countries. The expansion of agricultural areas required to increase the quantity of soybean produced may translate into degradation of natural ecosystems and land use changes, e.g. deforestation and clearance of native vegetation, as well as into social conflicts over land ownership which can lead to displacement of informal landowners (Baumann et al., 2017; Busscher et al., 2020; Cardozo et al., 2016; Krapovickas et al., 2016).

Studies from Paraguay, Argentina and Brazil, where almost all soybean production for international trade happens, show that the persistence of a weak land tenure system and the high presence of informal land ownership rights facilitates land grabbing and violent displacement of smallholder farmers (Busscher et al., 2020; Cardozo et al., 2016; Sauer, 2018). This is exacerbated by the high financialization of the land investment sector which involves transnational corporations that acquire land rights by negotiating directly with local government authorities that in many cases are formally and legally landowners. Busscher et al. (2020) discuss land grabbing in Argentina and highlight that possible ways to mitigate the phenomenon require both interventions at local level, such as supporting financially and legally informal landowners to formalize their land use rights, as well as supporting processes of negotiation between new settlers and informal landowners to minimise the risk of conflicts. Cardozo et al. (2016) discuss a case study in Paraguay where the indigenous community Ache' which informally owns communal agricultural land has negotiated a partnership with agribusiness companies to participate in mechanised soy production without transferring land rights to the soy investors.

Deforestation and clearance of native vegetation also leads to loss of ecosystem services provided by those ecosystems, such as carbon sequestration, pollination and biological control services as well as raw materials and wild food provision. Issues of land use change, deforestation and habitat conversion associated with soybean production and more in general with agricultural frontier expansion in Brazil and other South American countries have been addressed mainly by value chain initiatives, given that most production is exported toward Europe and China, such as the Amazon soy moratorium, the Round Table for Responsible Soy (RTRS) and voluntary standards included in international trade agreements (e.g. Europe – MercoSur trade agreement) (Ingram et al., 2018). Initiatives such as the certification for sustainable soy promoted by RTRS includes also sustainability standards that aim to mitigate negative social impacts and includes principles such as responsible labour conditions and community relations (RTRS, 2017). However, evidence regarding the effectiveness of such initiatives in terms of mitigating negative social impacts is scarce and fragmented.

The RTRS principles also incorporate standards about good agricultural practices which is the second main driver of impacts identified through the systematic literature review. As discussed in the sections above, intensive agricultural practices, inclusive of pesticides and fertilizers application, may lead to impacts on water pollution and eventually lead to health consequences for water users in the area (Almberg et al., 2014; Cardozo et al., 2016; Darré et al., 2019; Ruder et al., 2009). The use of pesticides may be detrimental also for workers health when spraying them across plantations and such risks may be reduced through the use of personal protective equipment and other working safety standards (Bernieri et al., 2019). Further, many environmental science studies investigated how conservation agriculture and other less intense agricultural practices may generate a lower impact on the ecosystem structure and the ecosystem services by reducing the amount of chemicals and pollutants inputted in the environment, minimising disturbances to soil by avoiding mechanised tillage and increase crop productivity through increasing pollination and biological control services offered by the presence of patches of forests and other natural areas within cropland areas.

Discussion

The results of the systematic review highlighted that there is actually little empirical evidence associated with soybean production in producing countries and such evidence portray a mixed picture of negative (14 counts) and positive impacts (20 counts) across the multiple dimensions of well-being that we examined. The well-being dimension relative to income seems to be the most studied, probably because such impact is somehow easier to measure through national statistics, and we found that the overall impact on income is mainly positive, confirming thus claims that trade will lead to average economic growth. The literature employing qualitative methods shows more evidence relative to intangible dimensions, such as cultural value, social relations and sense of security, and how actually soybean production seem to negatively affect those. This suggests that depending on the methods employed, qualitative vs quantitative, the impact on different well-being dimensions may emerge and mixed methods maybe needed to highlight possible trade-offs between negative and positive impacts of soybean production.

In terms of impacts on sustainability, using the Sustainable Development Goals, the evidence collected seems to indicate an overall positive effect on SDG 1 (No poverty), SDG 2 (Zero hunger), SDG 8 (Decent work and economic growth), SDG 10 (Reduced inequalities) while SDG 3 (Good health and well-being) and SDG 5 (Gender equality) seems to be negatively affected. However, given the very limited empirical evidence available these results need to be taken with extreme caution. The impact relative to SDG 1 and 10 for instance seems positive when looking at average increase in Brazil of income, poverty headcount and Gini index over 30 years (1990-2010), however when such impacts are examined in more detail at local level through qualitative fieldwork or more detailed quantitative analysis a different picture about inequality seems to arise. Weinhold et al. (2013) discusses how economic gains realised at municipality levels seem to be potentially distributed unequally, where ethnicity may play a role, and that this may generate or exacerbate tensions and social conflicts at local level. Similarly, Choi and Kim (2016) reveal that when looking at different soy production areas in a more disaggregated analysis the impact on reduction of poverty does not seem to be consistent across all geographical areas.

The overall picture portrayed by the review on indirect impacts, i.e. ecosystem service benefits, is much more homogeneous and shows that the only ecosystem service positively influenced by soybean production intensification is food production while all the other ecosystem benefits seem to be negatively affected. The most studied ecosystem services are carbon sequestration, especially given its relevance in a deforestation context, water quality and quantity regulation services and soil fertility, due to the intensification of agricultural practices which makes increase uses of agrochemicals and fertilizers as well as mechanised tillage. However, at least for half of the impacts recorded the indicators used measure the quality of the ecosystems and the potential impact on the supply of ecosystem services but they rarely quantify actual or potential impacts for human population well-being. For example, the amount of pesticides and other agrochemicals used on the soybean fields will impact the quality of surrounding groundwater and potentially impact also health of the population but these empirical links seem to be rarely studied and if studied just through theoretical modelling of future scenarios in combination with expert valuation (Maydana et al., 2020).

The role of policies has been barely studied within the well-being literature while it has been somehow studied more within the ecosystem service literature, especially given the high relevance of value chain initiatives which aims to mitigate environmental impacts associated with soybean production. As highlighted in the introduction, value chain initiatives and policies strongly focus on environmental impacts of soybean production and as such we found more empirical evidence relative to environmental impacts than social impacts. The results of the grey literature search, which did not provide any literature that fit our selection criteria, seem to point as well at the fact that within the international organizations and sectoral literature there may be a lack of focus on poverty and well-being as defined in broader terms. Jia et al. (2020) examined in more details the role of value chain governance for sustainable governance for soybean production by using a systematic review specifically focused on soybean and value chain governance, and similarly to our study found very little evidence regarding social impacts of soybean production. One reason of this lack of evidence may depends on the fact that the focus on social sustainability of value chain initiatives is limited to few specific aspects of soybean production: labour standards, land rights and community consultation and inclusion, but lack a more comprehensive consideration of all possible social impacts due to production and trade.

References

Almberg, K.S., Turyk, M., Jones, R.M., Anderson, R., Graber, J., Banda, E., Waller, L.A., Gibson, R., Stayner, L.T., 2014. A study of adverse birth outcomes and agricultural land use practices in Missouri. Environ. Res. 134, 420–426.

Auer, A., Maceira, N., Nahuelhual, L., 2017. Agriculturisation and trade-offs between commodity production and cultural ecosystem services: A case study in Balcarce County. J. Rural Stud. 53, 88–101.

Balmford, A., Fisher, B., Green, R.E., Naidoo, R., Strassburg, B., Turner, R.K., Rodrigues, A.S.L., 2011. Bringing ecosystem services into the real world: An operational framework for assessing the economic consequences of losing wild nature. Environ. Resour. Econ. 48, 161–175.

Baumann, M., Gasparri, N.I., Piquer-Rodriguez, M., Gavier-Pizarro, G., Griffiths, P., Hostert, P., Kuemmerle, T., 2017. Carbon emissions from agricultural expansion and intensification in the Chaco. Glob. Chang. Biol. 1902–1916.

Bernieri, T., Rodrigues, D., Barbosa, I.R., Ardenghi, P.G., Basso da Silva, L., 2019. Occupational exposure to pesticides and thyroid function in Brazilian soybean farmers. Chemosphere 218, 425–429.

Busscher, N., Parra, C., Vanclay, F., 2020. Environmental justice implications of land grabbing for industrial agriculture and forestry in Argentina. J. Environ. Plan. Manag. 63, 500–522.

Cardozo, M.L., Salas, D., Ferreira, I., Mereles, T., Rodríguez, L., 2016. Soy expansion and the absent state: indigenous and peasant livelihood options in eastern Paraguay. J. Lat. Am. Geogr. 15, 87–104.

Choi, S., Kim, H., 2016. The impact of conglomerate farming on the poor: Empirical evidence from the Brazil soy sector. Int. Area Stud. Rev. 19, 147–164.

D'Acunto, L., Semmartin, M., Ghersa, C.M., 2014. Uncropped field margins to mitigate soil carbon losses in agricultural landscapes. Agric. Ecosyst. Environ. 183, 60–68.

Dale, V.H., Polasky, S., 2007. Measures of the effects of agricultural practices on ecosystem services. Ecol. Econ. 64, 286–296.

Darré, E., Cadenazzi, M., Mazzilli, S.R., Rosas, J.F., Picasso, V.D., 2019. Environmental impacts on water resources from summer crops in rainfed and irrigated systems. J. Environ. Manage. 232, 514–522.

De Maria, M., Robinson, E.J., Rajabu, J., Kadigi, R., Dreoni, I., Couto, M., Howai, N., Peci, J., Fiennes, S., 2020. Global Soybean Trade. The Geopolitics of a Bean.

Drabik, D., de Gorter, H., Timilsina, G.R., 2016. Producing biodiesel from soybeans in Zambia: An economic analysis. Food Policy 59, 103–109.

Fearnside, P.M., 2001. Soybean cultivation as a threat to the environment in Brazil. Environ. Conserv. 28, 23–38.

Garrett, R.D., Levy, S., Gollnow, F., Hodel, L., Rueda, X., 2021. Have food supply chain policies improved forest conservation and rural livelihoods? A systematic review. Environ. Res. Lett. 16.

Garrett, R.D., Rausch, L.L., 2016. Green for gold: social and ecological tradeoffs influencing the sustainability of the Brazilian soy industry. J. Peasant Stud. 43, 461–493.

German, L., Schoneveld, G.C., Pacheco, P., 2011. The social and environmental impacts of biofuel feedstock cultivation: Evidence from multi-site research in the forest frontier. Ecol. Soc. 16, 26.

Greenpeace Brazil, 2018. Hold the Line: Agribusiness expansion and the dispute for the Cerrado. São Paulo.

Heilmayr, R., Lambin, E.F., 2016. Impacts of nonstate, market-driven governance on Chilean forests. Proc. Natl. Acad. Sci. U. S. A. 113, 2910–2915.

Heimpel, G.E., Yang, Y., Hill, J.D., Ragsdale, D.W., 2013. Environmental Consequences of Invasive Species: Greenhouse Gas Emissions of Insecticide Use and the Role of Biological Control in Reducing Emissions. PLoS One 8, 1–7.

Ingram, V., van den Bergh, J., van Oorschot, M., Arets, E., Judge, L., 2018. Governance Options to Enhance Ecosystem Services in Cocoa , Soy , Tropical Timber and Palm Oil Value Chains considering ecosystems and ecosystem services generally in. Environ. Manage. 128–142.

Jia, F., Peng, S., Green, J., Koh, L., Chen, X., 2020. Soybean supply chain management and sustainability: A systematic literature review. J. Clean. Prod. 255, 120254.

Koh, I., Holland, J.D., 2014. Grassland plantings and landscape natural areas both influence insect natural enemies. Agric. Ecosyst. Environ. 199, 190–199.

Koh, L.P., Nichols, J.D., Bailey, L.L., Jr., O.A.F., Talancy, N.W., Grant, E.H.C., Gilbert, A.T., Annand, E.M., Husband, T.P., Hines, J.E., 2008. Assessing ecological responses to environmental change using statistical models. J. Appl. Ecol. 45, 1321–1329.

Krapovickas, J., Sacchi, L.V., Hafner, R., 2016. Firewood supply and consumption in the context of agrarian change: The Northern Argentine Chaco from 1990 to 2010. Int. J. Commons 10, 220–243.

Lambin, E.F., Gibbs, H.K., Heilmayr, R., Carlson, K.M., Fleck, L.C., Garrett, R.D., Le Polain De Waroux, Y., McDermott, C.L., McLaughlin, D., Newton, P., Nolte, C., Pacheco, P., Rausch, L.L., Streck, C., Thorlakson, T., Walker, N.F., 2018. The role of supply-chain initiatives in reducing deforestation. Nat. Clim. Chang. 8, 109–116.

Lima, M., Skutsch, M., de Medeiros Costa, G., 2011. Deforestation and the social impacts of soy for biodiesel: Perspectives of farmers in the south Brazilian Amazon. Ecol. Soc. 16.

Malkamäki, A., Toppinen, A., Kanninen, M., 2016. Impacts of land use and land use changes on the resilience of beekeeping in Uruguay. For. Policy Econ. 70, 113–123.

Mann, M.L., Kaufmann, R.K., Marie, D., Gopal, S., Baldwin, J.G., Vera-Diaz, M.D.C., Bauer, D.M., Gopal, S., Baldwin, J.G., Del Carmen Vera-Diaz, M., 2012. Ecosystem Service Value and Agricultural Conversion in the Amazon: Implications for Policy Intervention. Environ. Resour. Econ. 53, 279–295.

Martinelli, L.A., Batistella, M., da Silva, R.F.B., Moran, E., 2017. Soy expansion and socioeconomic development in municipalities of Brazil. Land 6.

Maydana, G., Romagnoli, M., Cunha, M., Portapila, M., 2020. Integrated valuation of alternative land use scenarios in the agricultural ecosystem of a watershed with limited available data, in the Pampas region of Argentina. Sci. Total Environ. 714, 136430.

Meehan, T.D., Gratton, C., 2016. A landscape view of agricultural insecticide use across the conterminous US from 1997 through 2012. PLoS One 11, 1–17.

Mitchell, A.L., Rosenqvist, A., Mora, B., 2017. Current remote sensing approaches to monitoring forest degradation in support of countries measurement, reporting and verification (MRV) systems for REDD+. Carbon Balance Manag. 12.

Mitchell, M.G.E., Bennett, E.M., Gonzalez, A., 2014. Agricultural landscape structure affects arthropod diversity and arthropod-derived ecosystem services. Agric. Ecosyst. Environ. 192, 144–151.

Monasterolo, M., Musicante, M.L., Valladares, G.R., Salvo, A., 2015. Soybean crops may benefit from forest pollinators. Agric. Ecosyst. Environ. 202, 217–222.

Newton, P., Benzeev, R., 2018. The role of zero-deforestation commitments in protecting and enhancing rural livelihoods. Curr. Opin. Environ. Sustain. 32, 126–133.

Paul, B.K., Vanlauwe, B., Hoogmoed, M., Hurisso, T.T., Ndabamenye, T., Terano, Y., Six, J., Ayuke, F.O., Pulleman, M.M., 2015. Exclusion of soil macrofauna did not affect soil quality but increased crop yields in a sub-humid tropical maize-based system. Agric. Ecosyst. Environ. 208, 75–85.

Potschin, M.B., Haines-Young, R.H., 2011. Ecosystem services: Exploring a geographical perspective. Prog. Phys. Geogr. 35, 575–594.

Roe, D., Sandbrook, C., Fancourt, M., Schulte, B., Munroe, R., Sibanda, M., 2013. A systematic map protocol: which components or attributes of biodiversity affect which dimensions of poverty? Environ. Evid. 2, 1–8.

RTRS, 2017. RTRS Standard for Responsible Soy Production - Version 3.1. Buenos Aires.

Ruder, A.M., Carreón, T., Butler, M.A., Calvert, G.M., Davis-King, K.E., Waters, M.A., Schulte, P.A., Mandel, J.S., Morton, R.F., Reding, D.J., Rosenman, K.D., 2009. Exposure to farm crops, livestock, and farm tasks and risk of glioma. Am. J. Epidemiol. 169, 1479–1491.

Ruiz-Toledo, J., Vandame, R., Penilla-Navarro, P., Gómez, J., Sánchez, D., 2020. Seasonal abundance and diversity of native bees in a patchy agricultural landscape in Southern Mexico. Agric. Ecosyst. Environ. 292.

Russo Lopes, G., Bastos Lima, M.G., Reis, T.N.P. do., 2021. Maldevelopment revisited: Inclusiveness and social impacts of soy expansion over Brazil's Cerrado in Matopiba. World Dev. 139, 105316.

Saraiva Farinha, M.J.U., Bernardo, L.V.M., Soares Filho, A., Berezuk, A.G., da Silva, L.F., Ruviaro, C.F., 2019. Opportunity cost of a private reserve of natural heritage, Cerrado biome – Brazil. Land use policy 81, 49–57.

Sauer, S., 2018. Soy expansion into the agricultural frontiers of the Brazilian Amazon: The agribusiness economy and its social and environmental conflicts. Land use policy 79, 326–338.

Schleicher, J., Schaafsma, M., Burgess, N.D., Sandbrook, C., Danks, F., Cowie, C., Vira, B., 2018. Poorer without It? The Neglected Role of the Natural Environment in Poverty and Wellbeing. Sustain. Dev. 26, 83–98.

Sjauw-Koen-Fa, A.R., Blok, V., Omta, O., 2017. Exploring the applicability of a sustainable smallholder sourcing model in the black soybean case in Java. Int. Food Agribus. Manag. Rev. 20, 709–728.

Steward, C., 2007. From colonization to "environmental soy": A case study of environmental and socio-economic valuation in the Amazon soy frontier. Agric. Human Values 24, 107–122.

Syswerda, S.P., Robertson, G.P., 2014. Ecosystem services along a management gradient in Michigan (USA) cropping systems. Agric. Ecosyst. Environ. 189, 28–35.

UK NEA, 2011. The UK National Ecosystem Assessment Technical Report.

Vallecillo, S., La Notte, A., Zulian, G., Ferrini, S., Maes, J., 2019. Ecosystem services accounts: Valuing the actual flow of nature-based recreation from ecosystems to people. Ecol. Modell. 392, 196–211.

Villarini, G., Jones, C.S., Schilling, K.E., 2016. Soybean Area and Baseflow Driving Nitrate in Iowa's Raccoon River. J. Environ. Qual. 45, 1949–1959.

Villarino, S.H., Studdert, G.A., Baldassini, P., Cendoya, M.G., Ciuffoli, L., Mastrángelo, M., Piñeiro, G., 2017. Deforestation impacts on soil organic carbon stocks in the Semiarid Chaco Region, Argentina. Sci. Total Environ. 575, 1056–1065.

Virah-Sawmy, M., Durán, A.P., Green, J.M.H., Guerrero, A.M., Biggs, D., West, C.D., 2019. Sustainability gridlock in a global agricultural commodity chain: Reframing the soy–meat food system. Sustain. Prod. Consum. 18, 210–223.

Weinhold, D., Killick, E., Reis, E.J., 2013. Soybeans, poverty and inequality in the Brazilian Amazon. World Dev. 52, 132–143.

World Bank, 2019. World development report 2020: Trading for development in the age of global value chains.