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Review Article

Drivers to Adopt Activities Framed within Sustainable Agriculture

Impulsores para la adopción de actividades enmarcadas en la agricultura sostenible

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Abstract: Human activity in the agricultural sector has had environmental and social consequences on the sustainability of production practices. In environmental terms, conventional agriculture causes soil erosion, pollution and high consumption of bodies of water, greenhouse gas emissions, deforestation, and loss of biodiversity, among others. Through a systematic literature review, this article aims to identify the drivers that lead farmers to adopt or take on activities within sustainable agriculture. A search equation was designed with the most appropriate keywords, retrieving 118 articles. From the first filter, 47 articles were selected and read in full. A matrix was built with the following criteria: country of study, agricultural sector, activity adopted, driver, and its classification as external or internal to the farmer. Vantage Point 10.0 software was used to graph and analyze the results. Two hundred fifty-nine drivers were found. The main ones were education, membership in farmer organizations, family income, land tenure, access to the market, information and credit, farm size, age, and experience. The drivers can contribute to new studies on adopting or accepting these drivers in agricultural activities framed within sustainable agriculture.

Keywords: Sustainability, drivers, adoption, agricultural activities, sustainable agriculture.

Resumen: La actividad humana en el sector agropecuario ha tenido consecuencias ambientales y sociales en la sostenibilidad de las prácticas productivas. En términos ambientales, la agricultura convencional genera la erosión de suelos, la contaminación y el alto consumo de cuerpos de agua, las emisiones de gases de efecto invernadero, la deforestación, la pérdida de biodiversidad, entre otras. El objetivo de este artículo fue el de identificar por medio de una revisión sistemática de la literatura los impulsores que llevan a los agricultores a adoptar o asumir actividades enmarcadas en la agricultura sostenible. Se diseñó una ecuación de búsqueda con las palabras clave más adecuadas y se recuperaron un total de 118 artículos. Del primer filtro se seleccionaron 47 artículos que se leyeron en su totalidad y se construyó una matriz con los siguientes criterios: país de estudio, sector agrícola, actividad adoptada, impulsor y clasificación de externo o interno al agricultor. Se utilizó el software Vantage Point 10.0 para graficar y analizar los resultados. Se encontraron 259 impulsores; los principales fueron la educación, la afiliación con organizaciones de agricultores, los ingresos familiares, la tenencia de la tierra, el acceso al mercado, a la información y al crédito, el tamaño de la finca, la edad y la experiencia. Estos impulsores pueden contribuir a nuevos estudios sobre la adopción o aceptación de estos en las actividades agrícolas enmarcadas en la agricultura sostenible.

Palabras clave: sostenibilidad, impulsores, adopción, actividades agrícolas, agricultura sostenible.

Introduction

In 1987, the Bruntdland Commission released the report "Our common future," which defined sustainability as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). With a continuously growing population, producing more food with the Earth's finite resources while reducing the environmental impacts requires sustainable intensification, changing agronomic practices, and adopting activities such as integrated pest management and agroforestry (Charles et al., 2010).

Nevertheless, agricultural activities have specific characteristics that harm and benefit environmental quality. Traditional farming can deteriorate the soil, water, and air quality, causing a loss of habitats and biodiversity. Still, it has positive impacts, such as acting as a sink for greenhouse gases, conserving and enhancing biodiversity, and preventing flooding and landslides. Agricultural systems must be improved to face the challenges of increasing food production to solve hunger problems and maintaining food production while increasing environmental goods and services (Pretty, 2016).

Just like the word sustainability, the concept of sustainable agriculture is ambiguous. The US Congress defined it in 1990 as an integrated system of plant and animal production practices having a site-specific application that will, over the long term: (a) satisfy human food and fiber needs; (b) enhance environmental quality; (c) make efficient use of non-renewable resources and on-farm resources and integrate appropriate natural biological cycles and controls; (d) sustain the economic viability of farm operations; and € enhance the quality of life for farmers and society as a whole. (Public Law 101-624, 1990).

Sustainability in agriculture is a dynamic concept that includes environmental, social, economic, and resource use that can vary with time, location, society, and priorities. Its primary intention is to minimize external inputs and maximize outputs while maintaining the resources and achieving socioeconomic, environmental, and economic welfare (Mishra et al., 2018). Sustainable agriculture requires integrating practices framed within sustainability that are productive, competitive, and efficient while protecting and improving local communities' environment, ecosystem, and socioeconomic conditions (Mishra et al., 2018).

The Driving Force-State-Response framework "considers the specific characteristics of agriculture and its relation to the environment," addressing a set of questions such as: "What is causing environmental conditions in agriculture to change (driving force)? What actions are being taken to respond to changes in the environment in agriculture (response)?" (Organization for Economic Co-operation and Development [OECD], 1999). The analysis derived from addressing these questions can help to understand the response and feedback by farmers, policymakers, and society. Driving forces cause environmental changes and cover the influences in sustainable agriculture, such as farmer behavior, policies, and other factors (Jambo et al., 2019). The University of Alberta states, "Adopting sustainable practices, whether large or small, can have significant impacts in the long run" (University of Alberta, 2013). This statement supports the aim of this study, which is to conduct an in-depth literature review to identify the

drivers in the agriculture sector and boost the effective deployment of methodologies, mechanisms, and strategies focused on the transition to sustainable development in the industry.

Section 1 of the article is the theoretical framework, followed by Section 2, the methodology, which is divided into four stages. Section 3 shows the results from the literature review, which were analyzed qualitatively using the software Vantage Point 10.0; Section 4 presents the discussion regarding the results, and Section 5 concludes.

This article can represent an essential input for academics willing to implement initiatives that seek to understand, take advantage of, and potentiate the internal and external drivers that facilitate adopting agriculture practices or projects framed within sustainability and the success of practical implementations.

Materials and Methods

Generally, a literature review can be defined as selecting available information on a specific topic and effectively evaluating this documentation for proposed research (Hart, 1998). The most common classification of literature reviews divides them into narrative literature reviews, systematic literature reviews, and meta-analyses (Cronin et al., 2008).

In this context, we have chosen a qualitative approach similar to that proposed and applied in literature review methodologies published in different agroindustry studies: Ciprian et al. (2022), Hernandez et al. (2021), Solarte et al. (2021), and Zartha et al. (2021b,c). Innovation and technology management studies include Zartha et al., 2021a, while sustainability was addressed by Álvarez et al. (2019) and Betancourt and Zartha (2020).

The first stage of the literature review was the selection of Scopus as the primary source of information and the keywords that would help achieve the objective of the study, which were "driver," "adoption," or "uptake," "sustainab*," and "agriculture." Next, the search equation was constructed: TITLE-ABS-KEY (driver AND (adoption OR uptake) AND sustainab* AND agriculture), resulting in 118 articles. The abstracts of all articles were reviewed, so 47 papers were selected for the literature review regarding situations where there was a transition toward sustainable agriculture practices. The drivers that allowed and facilitated their adoption were further analyzed.

An Excel table was created with the following fields to facilitate the analysis: name of the article, abstract, keywords, if the paper has a literature review as part of its methodology, authors, year, country of the authors, place of study, source, Scimago Journal Rank, Scimago Quartile, agriculture sector, methods used to find drivers, drivers, sustainable agriculture activity adopted, and classification depending on whether the driver is external or internal to the farmer.

Once the 47 selected articles had been read, Vantage Point 10.0 was used as a source of analysis, with a table with the following categories as input: abstract, keywords, year of publication,

journal, country of the authors, place of study, Scimago Journal Rank, and Scimago Quartile. Figure 1 shows all the stages of the methodology.

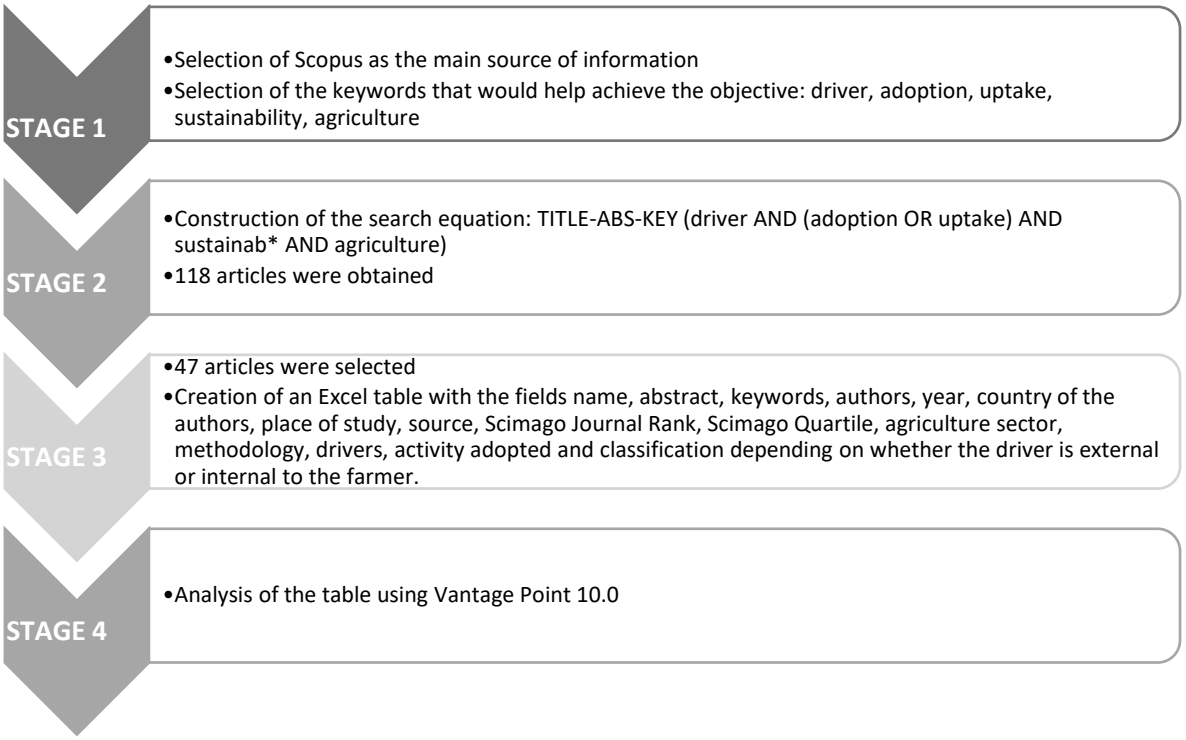

Figure 1. Stages of the Methodology
Source: Prepared by the authors

Results

This section shows the results from the analysis of the 47 selected articles, where the relationship with the objective of this article is explicitly understood from their title, abstract, and keywords. The figures and tables below were constructed considering relevant information from each article, such as keywords, place of study, year of publication, source of information, Journal's SJR, and Scimago quartile.

As mentioned above, the systematic literature review was followed as the methodology for this article to determine how many articles had this same methodology for their construction. As shown in Figure 2, 38 % of the analyzed articles followed a literature review as part of their methodology, and the remaining 62 % did not.

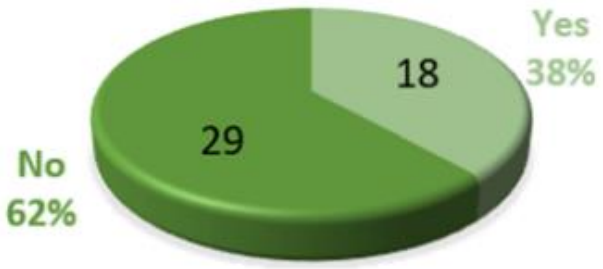

Figure 2. Articles with Literature Review
Source: Prepared by the authors

Since the year of publication was not taken into consideration in the structuring of the search equation, the 47 articles selected were grouped into periods (Figure 3) as follows: between 2004 and 2008, five articles; between 2009 and 2012, seven articles; between 2013 and 2016, 12 articles, and finally, between 2017 and 2020, 23 articles.

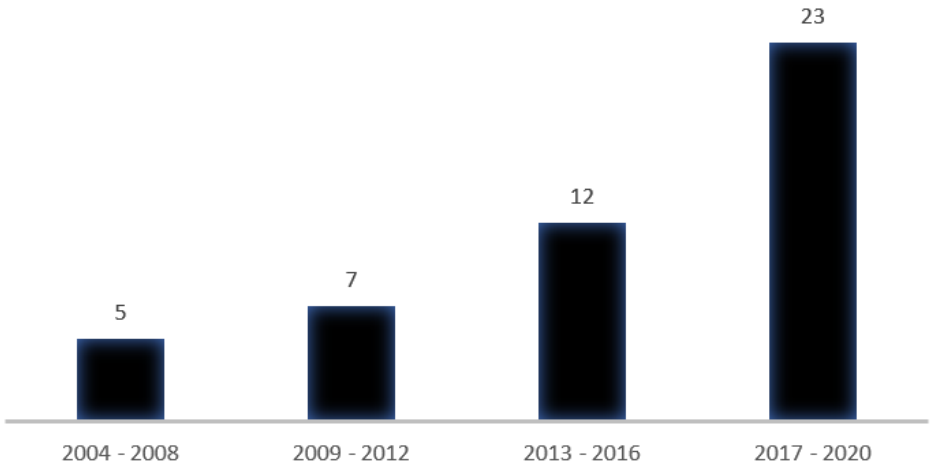

Figure 3. Articles published per period
Source: Prepared by the authors

The Table 1 is presented below, which lists the studies in the period between 2004 and 2020.

Table 1. Description of the studies by period

Period	Author	Description of the study
2004-2008	Vanclay (2004)	presented the most relevant social principles for promoting natural resource management practices in agriculture, reinforcing the technical and economic principles for the transition toward sustainable agriculture. Ostendorf (n.d.) explained the drivers and determinants of adopting Natural Resource Management practices in some grain-producing farms in Australia.
	Jera and Ajayi (2008)	evaluated the drivers of adopting forage bank technologies by small farmers in Zimbabwe, understanding their importance for developing appropriate technologies for farmers.
2009 - 2012	Bond (2009)	examined different contexts of land use in the Podocarpus National Park in Ecuador, evaluating the barriers and drivers of adopting agroforestry practices by small farmers.
	Wyckhuys and O'Neil (2010	discussed farmers' decision-making about the management of pests in corn production in Honduras, understanding these ecological processes, and how the local diffusion networks and the social connection of farmers influenced the adoption of Integrated Pest Management practices.
	Sassenrath et al. (2010)	examined agricultural production systems in the United States through interviews and discussions to explore the key drivers of adopting sustainable farming practices, dividing them into internal and external social, economic, and environmental drivers.
	Bosma et al. (2012)	investigated the drivers of adopting Integrated Rice and Fish Farming Systems in Vietnam to support policy making, land use planning for agricultural purposes, and the extension of integrated rice and fish farming.
2013-2016	Codron et al. (2014)	analyzed the drivers of adopting sustainable agricultural practices external to farmers from tomato farms in Morocco and Turkey, focusing on market forces and food security institutions.
	Ahmad et al. (2014)	evaluated the reasons for adopting Resource Conservation Technologies in Pakistan's rice and wheat cropping systems and their impacts on land productivity.
	Antille et al. (2015)	analyzed some of the main benefits of adopting Controlled Transit Agriculture and other activities. Also, they reviewed the drivers of adopting this activity based on experience from Australia and the United Kingdom.
	Sietz and van Dijk (2015)	presented a meta-analysis of the drivers of adopting resource conservation measures in drylands in West Africa.

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	Lalani et al. (2016)	studied through a socio-psychological model the drivers that had led farmers to adopt Conservation Agriculture in Cabo Delgado, Mozambique.
2017-2020	Padilla-Bernal et al. (2018)	studied the drivers and barriers to adopting voluntary Environmental Management Systems mechanisms in Mexico's vegetable sector.
	Schleifer (2017)	looked at the different levels of success of two similar certification programs for the sugarcane and soy sectors, understanding the drivers for their adoption in Brazil
	Kpadonou et al. (2017)	analyzed the determinants of adopting soil and water conservation practices in the Sahel of West Africa.
	Kurgat et al. (2018)	examined the adoption rate of Sustainable Intensification Practices and their adoption drivers among smallholder farmers in rural Kenya.
	Tambo and Mockshell (2018)	analyzed the impact of Conservation Agriculture practices and the drivers of adoption among corn producers in nine Sub-Saharan African countries.
	Bunclark et al. (2018)	studied the drivers of adopting and using water harvesting technologies among farmers in Burkina Faso.
	Abeje et al. (2019)	examined the factors driving the adoption of Sustainable Land Management practices among 270 households in the Blue Nile Basin, Ethiopia.
	Jezeer et al. (2019) studied	studied the influence of livelihood assets, experienced crises, and perceived risks for adopting sustainable coffee-growing practices by small farmers in Peru.
	Le and Dhehibi (2019)	studied the determinants of the adoption of Mechanized Raised-Bed Technology among farmers in Egypt.
	Kumar et al. (2020)	checked the drivers of adopting technologies and improved production practices among farmers in Nepal.
	Jack et al. (2020)	investigated the factors that drive farmers to participate in extension, learning, and consulting programs in Northern Ireland
	Guo et al. (2020)	investigated the determinants of adopting sustainable intensification practices through a Southern African Development Community literature review.
	Latifi et al. (2020)	investigated the institutional drivers of promoting Conservation Agriculture practices to present a model that provided a promotion guide in Iran.

Source: Prepared by the authors

As shown in Figure 4, the subject matter of 58 % of the articles was located in countries from Africa, mainly Tanzania and Malawi, followed by Europe with 12 % of the articles reviewed and Asia and North America with 8 % each.

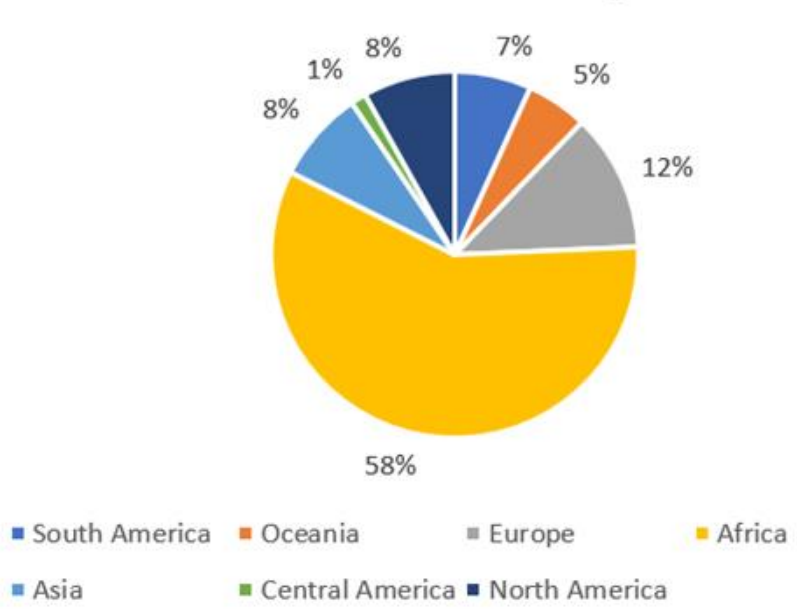

Figure 4. Continent of Study
Source: Prepared by the authors

One of the most common keywords among the articles reviewed was "Adoption," which was used in eight articles (17 %), followed by "Conservation Agriculture" and "Sustainable Agriculture," which were used in five articles, respectively. "Drivers" was a keyword in two articles reviewed. However, it was common to find this word accompanying others such as "External drivers," "Socioeconomic drivers," "Social drivers," "Economic drivers," "Social/political drivers, "Environmental drivers, "and" Technological drivers, "for a total of seven articles (14 %).

Drivers for the adoption of sustainable agriculture activities

The objective of this study was to analyze the different drivers or change-makers that allow the adoption of sustainable practices in the agricultural sector in different situations. Each driver was classified as "internal" or "external." It was considered internal if the driver was within the limits of the production system and, therefore, under the farmer's control or external if the driver was not under the farmer's control. For each situation, we analyzed which sustainable agriculture activity was intended to be adopted, the agricultural sector of the case study, and the country where the study was carried out.

Table 2 is presented below, where some internal variables analyzed are observed.

Table 2. Studies on internal drivers

Author	Description of the study
Le and Dhehibi (2019)	studied the importance of the socio-ecological context of farmers and its influence on adopting new technologies. Through primary data collection, they found that age, education, and membership in farmers' organizations, among others, are the common and specific determinants of the adoption of sustainable water use technologies in populations in Egypt.
Walder et al. (2019)	explored the relationship between farmers' innovation decisions and their values through a collection of primary data in a sample of 174 Austrian farmers, where they found that education, off-farm employment, and the values and goals of self-fulfillment and hedonism are the main drivers of innovation
Tambo and Mockshell (2018)	analyzed the impact of Conservation Agriculture activities on household well-being, studying the factors that influenced its adoption, through surveys of corn farmers, in countries of Sub-Saharan Africa. They found that education, access to credit, land tenure, and membership in farmers' organizations, among others, are drivers of the adoption of CA activities
Lemken et al. (2017)	studied the drivers of adopting multiple cultivation practices in Germany through the Transtheoretical Model of Behavior Change. They collected primary data, concluding that land ownership and household income positively affect the adoption process.
Kpadonou et al. (2017)	Analyzed the drivers of adopting Climate-Smart Agriculture practices through the joint analysis framework. They found that the main drivers of adoption and intensification of the use of these practices are the presence of children between 6 and 14 years old, land tenure, awareness, and training. Through a literature review, they reviewed the influences of psychological, social, and cognitive factors on adopting biosecurity practices in agricultural systems, thus finding drivers such as perceptions of threat, norms, perceived costs, and resilience.
Sassenrath et al. (2010)	Analyzed through interviews and discussion approaches with producer panels that age, being a farmer as a lifestyle, and having a strong identity with the community are drivers that impact the adoption of sustainable agriculture management practices in the United States
Jera and Ajayi (2008)	Assessed small farmers' adoption of forage bank technology in Zimbabwe to develop appropriate technology and extension packages that could be adapted to dairy farmers. This adoption was facilitated by drivers such as dairy herd size, land size, and years of membership in a dairy association.

Source: Prepared by the authors

During the review, 14 articles reported drivers considered external, as shown in Table 3. Most authors found both types of drivers in their papers, internal and external (Table 3).

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Table 3. Studies on both types of drivers

Author	Description of the study
Kumar et al. (2020)	used the example of the Nepal-based Integrated Sustainable Agriculture project to identify drivers for adopting improved production practices and technologies. Through primary data collection and the Poisson regression method, they found that the main drivers of adoption were access to markets, education, membership in farmer organizations, and participation in agricultural training, among others.
Jack et al. (2020)	explored and analyzed why farmers in Ireland joined and participated in the Farm Business Development Group (BDG), which aims to increase access to services for farmer extension workers to promote sustainable agricultural practices.
Guo et al. (2020)	), through a literature review and a mixed methods approach, concluded that the land area, age, openness to finding and using information, and ensuring access to government plans and support are the main drivers. Through a literature review, they analyzed the determinants of adopting sustainable intensification practices in agricultural systems in the Southern African Development Community countries. As a result of the meta-analysis, they found that the main drivers of adoption are land size, education, extension services, farm size, and access to credit.
Safari et al. (2019)	focused on the perception of forage conservation practices called Ngitili, their perceived benefits, and the definition of socioeconomic variables that explained their adoption through data collection in primary schools in Maswa District, Tanzania. As a result, they found that education, the need for dry season forages, and the benefits associated with livestock production were the main drivers of adopting the practice.
Jambo et al. (2019)	identified farmers' motivations to use sustainable intensification practices, analyzing the attitudes, benefits, and barriers of this practice by collecting primary data and surveying small farmers in Tanzania and Malawi. Some of the adoption drivers mentioned were economic reasons, peer pressure, environmental protection value, and land attachment value.
Teshager et al. (2019)	analyzed the relationship between the diversification of livelihoods and the adoption of Sustainable Land Management practices through the collection of primary data among farmers in Ethiopia, thus finding that a lower degree of diversification of livelihoods, education, access to credit, and experience were the factors driving the adoption of these practices.
Kurgat et al. (2018)	Through primary data collection, selected 685 rural and periurban vegetable farms to understand sustainable intensification practices in Kenya. They concluded that education, farmer attitudes towards risk, land tenure, access to farmer groups, and information drove the adoption of improved irrigation systems, organic compost, or management-integrated soil fertility.
Bunclark et al. (2018)	presented their research carried out between 2013 and 2014 on identifying drivers of adopting and using water harvesting technologies in Burkina Faso, including access to transport, farming technologies, credit, institutional support, and community support.
PadillaBernal et al. (2016)	identified the factors determining the intention to adopt an Environmental Management System in the vegetable sector in Mexico through the collection of primary data, thus finding that access to markets, the reduction of production costs, and education are some drivers of adoption.
Joffre et al. (2015)	studied the factors driving the adoption of integrated shrimp aquaculture in mangroves in Vietnam. Their study was carried out through a literature review and secondary data collection derived from panels of international and Vietnamese experts, concluding that

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	access to premium markets, market price fluctuation, access to credit, and membership in farmers' organizations, among others, are some of these factors.
Lefebvre et al. (2015)	Using a literature review, explored the factors that directed the adoption of new phytosanitary practices and integrated pests in Europe to answer the following questions: (1) when the guidelines have not yet been implemented, what incentives would encourage European farmers to adopt these guidelines? (2) How and to what extent should public funds be used to promote the adoption of guidelines? Some factors they found were the cost-effectiveness of integrated pest management technology, market access, farmers' attitudes toward risk, and regulatory instruments, among others.
Avolio et al. (2014)	studied the diffusion of innovation in Italian agriculture by providing a map of the diffusion of innovations, highlighting the differences and territorial specificities, and explaining the drivers and factors that influenced them. They concluded that the distribution of different types of innovation is not uniform in the country and that they are specific depending on the market opportunities.
Hinojosa-Rodríguez et al. (2014)	investigated the diffusion of integrated production in the olive growing sector in Andalusia, the largest in the world, and the factors that have conditioned such dissemination through a survey of 400 farmers. Affiliation with farmers' organizations, sources of information internal to the agricultural system like other farmers, self-study, agricultural associations, and market access are those factors.

Source: Prepared by the authors

Appendix 1 shows the compilation of the 259 drivers found in the literature review, which has different categories such as their classification of external or internal, country of study, sector, and the sustainable activity to be adopted.

An additional analysis was carried out in Vantage Point with the top 11 Drives and top 11 keywords through a co-occurrence matrix ending in a Bubble chart. The results of this analysis are presented in Figure 5, highlighting the contributions of 11 drivers to adoption, ten to livelihood, eight to sustainability, eight to conservation, six to sustainability agriculture, five to technology adoption and sustainable intensification, two to water conservation, and one to agriculture and natural recovery. Regarding the keywords, three thematic groups can be noted: sustainability, which encompasses the keywords sustainability, sustainability agriculture, sustainable development, and sustainable intensification; technology adoption, which includes adoption; and natural resources, which encompasses variables such as conservation.

Figure 5. Keywords of Analyzed Articles
Source: Prepared by the authors

Conclusion

During the literature review of the 47 papers, we identified 259 drivers for adopting sustainable agriculture activities. The driver occurring the most was "Education," which was present in 13 papers, followed by "Affiliation with farmers' organizations" in seven articles. Of note is that the drivers "Household income," "Land tenure," and "Market access" appeared in six articles, respectively. In 27 articles, the agriculture sector was not specified, so we decided to set it as "General agriculture." Horticulture and maize production are sectors that appeared three times respectively in the review. Conservation agriculture was the sustainable agriculture activity whose adoption was studied the most. Other activities were Environmental Management Systems, Integrated Pest Management, and Sustainable Intensification Practices, which were analyzed in three articles, respectively. As part of the literature review, the authors analyzed external and internal drivers; in most cases, both types were studied. In 24 articles, the authors studied both types, representing 51 %. Fifteen articles (32 % of the papers) presented only external drivers, and the remaining 17 % were only internal.

The countries of study of 58 % of the articles are in Africa, mostly Malawi, Tanzania, Burkina Faso, and Mozambique. Regarding the Americas, the United States was the country where most of the studies were conducted, followed by Mexico and Brazil.

During the literature review, it was necessary to include the keywords "adopt" and "uptake" to direct better the search equation because the word "driver," used alone, was related to agriculture as a driver of negative impacts, such as deforestation, greenhouse gas emissions, soil erosion, among others. This may represent an opportunity for a new literature review where other words that replace the word "driver" are investigated to get a complete vision of the drivers of sustainable agriculture and not only the adoption process of activities framed within sustainable agriculture. Since "innovation" appeared in two articles, we recommend including this keyword because the transition to sustainable agriculture could mean innovation in many practices being carried out on the farm and considered new to the farmers.

This article can represent an essential input for academics willing to implement initiatives that seek to understand, take advantage of, and potentiate the internal and external drivers that facilitate adopting agriculture practices or projects framed within sustainability and the success of practical implementations. The compilation and classification of the drivers constructed in this literature review could be helpful for companies that work with farmers and need to structure a strategy for adopting sustainable agriculture activities. Also, understanding the external drivers presented here by people working in the public sector can help design sustainable public policies for the primary sector so the farmers' perspectives are considered.

Ethical implications

The authors have no ethical implication in this article.

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Authors' contributions

Mariana Herrera Arango and Laura Restrepo Campuzano read the papers and classified the drivers. Gina Lia Orozco Mendoza constructed the search equation and used the Vantage Point software. Gustavo Adolfo Hincapie Llanos and Jhon Wilder Zartha Sossa reviewed the paper in general and contributed to the respective analysis of results and conclusions.

Conflict of interest

The authors state no conflict of interest.

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