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Agricultural land systems importance for supporting food security and sustainable development goals: A systematic review

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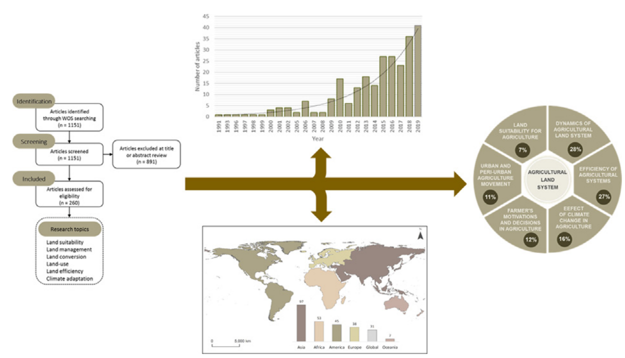
HIGHLIGHTS

- Agricultural land systems research is centred on six main subjects.
- Agriculture land systems is relevant to 11 of the 17 SDGs.
- Limited studies on climate adaptation, land management and land suitability subjects
- Developed regions are underrepresented in this scientific domain.
- Agricultural land systems research is important to food security.

GRAPHICAL ABSTRACT



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ABSTRACT

Agriculture provides the largest share of food supplies and ensures a critical number of ecosystem services (e.g., food provisioning). Therefore, agriculture is vital for food security and supports the Sustainable Development Goal (SDGs) 2 (SDG 2 - zero hunger) as others SDG's. Several studies have been published in different world areas with different research directions focused on increasing food and nutritional security from an agricultural land system perspective. The heterogeneity of the agricultural research studies calls for an interdisciplinary and comprehensive systematization of the different research directions and the plethora of approaches, scales of analysis, and reference data used. Thus, this work aims to systematically review the contributions of the different agricultural research studies by systematizing the main research fields and present a synthesis of the diversity and scope of research and knowledge. From an initial search of 1151 articles, 260 meet the criteria to be used in the review. Our analysis revealed that most articles were published between 2015 and 2019 (59%), and most of the case studies were carried out in Asia (36%) and Africa (20%). The number of studies carried out in the other continents was lower. In the last 30 years, most of the research was centred in six main research fields: land-use changes (28%), agricultural efficiency (27%), climate change (16%), farmer's motivation (12%), urban and peri-urban agriculture (11%), and land suitability (7%). Overall, the research fields identified are directly or indirectly linked to 11 of the 17 SDGs. There are essential differences in the number of articles among research fields, and future efforts are needed in the ones that are less represented to support food security and the SDGs.

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1. Background

Since the 1996 World Food Summit (WFS), massive efforts have been made in increasing agriculture food production and security (Ericksen, 2008; FAO, 2017). More recently, in 2015, the United Nations (UN) set the 17 Sustainable Development Goals (SDGs), where an essential goal is Zero Hunger (SDG 2). Despite the great efforts carried out in the last decades in developing strategies and policies towards the achievement of global food security, nowadays, approximately one in ten persons worldwide are suffering from severe levels of food insecurity (FAO et al., 2020). The demographic growth, accelerated urbanization (FAO, 2017; Tomlinson, 2013), the non-sustainable consumption of non-renewable resources (Popp et al., 2014; Tilman et al., 2011), climate change (Abd-Elmabod et al., 2020; IPCC, 2014; Schmidhuber and Tubiello, 2007), the changing of food consumption pattern (e.g., increase in overall calorie intakes; diet structure changes towards increase of meat, eggs, among others products) (Godfray et al., 2010; Guyomard et al., 2012; Hatab et al., 2019; Kastner et al., 2012), will put important challenges in food security. Population growth is expected to increase undernourishment (Hall et al., 2017), while the intensive exploitation of resources may lead to land degradation and reduce soil productivity (Tóth et al., 2018). The increase of extreme events (e.g., droughts and floods) and the increasing frequency of pests and diseases associated with climate change can be responsible for crop failure or destruction (e.g., Richardson et al., 2018; Spence et al., 2020). Finally, the changing of food patterns and the demand for more products is increasing the demand for land and water resources, exhausting the resources and increasing the uncertainty regarding food security. Therefore, the food and nutrition security agenda calls for urgent international efforts with effective global food security insurance (FAO et al., 2020; Ruben et al., 2018; Schneider et al., 2011).

Agricultural land provides the largest share of food supplies and ensures an essential number of ecosystem services (e.g., providing food, fuel, fibre) (Pereira et al., 2018; Scown et al., 2019; Stephens et al., 2018). Mainly, agricultural land contributes (directly or indirectly) to approximately 90% of food calories (Cassidy et al., 2013) and 80% of protein and fats (livestock production) (Steinfeld et al., 2006). Therefore, agricultural areas support food security and SDGs achievement (Avtar et al., 2020; DeClerck et al., 2016; FAO, 2017; Godfray et al., 2010; Wu et al., 2014). Also, agriculture, especially when practised sustainably, is dependent, connected or essential to improve other SDG's. For instance, it is vital to reduce poverty (Goal 1-No poverty; e.g., targets 1.4 and 1.5). Increase population wellbeing (Goal 3-Good Health and Wellbeing; e.g., target 3.9) and support knowledge and R&D (Goal 4-Quality education; e.g., target 4.7). Improve water quality and use efficiency (Goal 5-Clean water and Sanitation; e.g., targets 6.3 and 6.4), energy efficiency and investment in clean energy (Goal 6- Affordable and Clean Energy; e.g., targets 7.2. and 7.3). Also, it is essential to improve the farmers working conditions and resource efficiency use (Goal 8- Decent work and economic growth; e.g., targets 8.2, 8.3 and 8.4), support small scale farmers and promote innovation (Goal 9- Industry Innovation and Infrastructure; e.g., targets 9.3 and 9.4) and improve a fair trade between producers and consumers (Goal 10- Reduced Inequalities; e.g., target 10.a). Agriculture contributes to the increase of urban areas livability and access to green spaces (e.g., urban gardens, green roofs), reduce the impact of natural hazards and pollution and ensure food security (Goal 11- Sustainable Cities and Communities; e.g., targets 11.5, 11.6, 11.7 and 11.a). Agriculture friendly practices contribute to the efficient management of natural resources (e.g., soil and water) and reduce food waste and waste production (Goal 12- Sustainable Cities and Communities; e.g., targets 12.1, 12.2, 12.3, 12.4 and 12.5), to reduce the greenhouse gases emissions and mitigate the impacts of climate change-related events (Goal 13-Climate Action; e.g., target 13.1), to decrease the agrochemicals application and the pollution of surface water bodies (Goal 14- Life Bellow Water; e.g., target 14.1) and to reduce the intensive agriculture practices (e.g., deep tillage, agrochemicals application), deforestation and land degradation (Goal 15-Life on Land; e.g., targets 15.1; 15.2; 15.3, 15.4 and 15.5). Unsustainable agriculture practices that may lead to resource exhaustion or land degradation may trigger conflicts. Therefore, sustainable land management is key to reducing the conflicts resulting from the lack of food (Goal 16-Peace Justice and Strong Institutions) (United Nations, 2015a). Although agriculture has an essential role in improving an important number of SDG's, several works highlighted the existence of tradeoffs between SDG's. For instance, the increase of food production to support No Poverty (Goal 1) or Zero Hunger (Goal 2), may have negative implications in the achievement of other goals such as Climate Action (Goal 13), Life Bellow Water (Goal 14) and Life on Land (Goal 15) (e.g., Bowen et al., 2017; Moyer and Bohl, 2019; Yang et al., 2020). To minimize the tradeoffs associated with agriculture impacts, it is vital to invest and develop new technologies for data acquisition (e.g., remote and proximal sensing) and create robustly and validated models that consider data from multiple sources (Brevik et al., 2016; Gomes et al., 2021). This will be essential to identify accurately where the agriculture areas are more productive and where they can have more detrimental impacts on the ecosystems. This will be vital to have better agricultural land management. However, for this to be fully operational interdisciplinary research is needed (Pereira et al., 2018a).

Several studies have been focused on the global challenge of increasing food security from an agricultural land systems perspective (i.e., a man-made system created with the purpose of livestock and cropland production) (e.g., Antle et al., 2017; Stephens et al., 2018; Wu et al., 2014; Yu et al., 2012). The works carried out are very heterogenous (Koutsos et al., 2019) from different scientific disciplines (e.g., geography, ecology, soil science, agronomy, economy) (Jones et al., 2017). Few works (e.g., Van Noordwijk et al., 2018; Nicholls et al., 2020) have been carried out on revision or systematization of the published research studies about agriculture and how they contribute to SDG's achievement. Therefore, based on a systematic literature review, this study aimed to assess knowledge on agricultural land system research. The specific objectives are 1) Identify and describe the principal research fields of the published research studies from an agricultural land system perspective; 2) Link the identified research fields to SDG's; 3) Assess the tradeoffs associated with agricultural systems and 4) Demonstrate the current methodological research directions. This study provides an essential synthesis to understand the main focus of agricultural land system research, where they were conducted, the methodological approach, and how they support food security and the SDGs.

2. Systematic review framework

2.1. Search strategy, keywords and criteria of selection

A systematic review of the literature was conducted following the framework developed by Koutsos et al. (2019). The method follows six steps: 1) scoping, 2) planning, 3) identification and search, 4) screening articles, 5) eligibility assessment, and 6) presentation and interpretation. 1) scoping: the protocol for the review was defined. In this study, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement protocol (Moher, 2009) was chosen to guarantee the scientific quality and ensure a transparent, systematic review. 2) planning: the suitable databases were identified, and the search strategies were developed. This study opted to include only the WOS database because we wanted to select the articles going through a rigorous peer-review process and (theoretically) are considered in indexed journals. Furthermore, because the agricultural land system is a vast topic, we combined different relevant keywords and boolean operators related to the study aim using the search string: "TI =(agricultur* AND land* OR cultivat* AND land* OR crop* AND agricultur*) AND TS = (food)" (we assumed "Agricultural land" and "Cultivated land" interchangeably). 3) identification and search: the articles to include from the database were retrieved and identified. The search was conducted in January 2020. In total, 1151 articles were selected. 4) screening: the identified articles were filtered to meet the determined criteria: documents typeset as articles; peer-review scientific journals; published until 2019; English language; and related to agricultural land for food-grain crops (food human consumption). Therefore, after the title and abstract reading, 851 articles were excluded because they were focused on other types of agricultural production, such as, e.g. the production of feed, energy fuel/biofuel, the study of mammals, impacts of agricultural land on the ecosystems. 5) eligibility assessment: the full-text articles that do not meet the criteria were excluded. In total, 260 articles were identified as eligible for the review (Supplementary material 1). After a detailed analysis of the articles, they were grouped into six different topics: land suitability (i.e. best location for specific land use), land management (i.e., control the use and development of land resources), land conversion/change (i.e., the transformation of the natural landscape), land use (i.e., the human use of land), land efficiency (i.e., managing land use under land policies and principles of sustainable development), and climate adaptation (i.e., adaptation of natural or human systems to the current or predicted climate change and their effects). These research topics are broadly related to food security and agricultural land systems and were adopted from Wu et al. (2014) and Yu et al. (2012), both review articles propose strategies to raise future food production and describe global change/food security studies. Group the included research articles is a crucial step because of the heterogeneity of the studies and allows to summarize and describe their methodological directions. Thus, if the article primarily assessed one of these six research topics, it was assigned to one broad research field. 6) interpretation and presentation: the article's content, i.e., the publication year, geographic coverage, approach, methodological characteristics, reference data used, were identified and synthesized. Since this is a review article, more minor detail will be provided regarding the theoretical and methodological approaches of each individual article and statistical analysis due to differences in each article objectives, scientific field background, data availability, or other technological used sources. Finally, after grouping the included articles by each research field, we provide a logical relation between the different research fields and the SDG's based on current literature and the author's understanding of the topic. The description and supporting references are not directly related to the selected articles from the systematic literature review. The framework applied in this work is sensitized in Fig. 1.

3. Results and discussion

3.1. The historical and geographical context of the articles

The number of articles published per year is shown in Fig. 2. The evolution of the number of works can be divided into three stages: 1) 1991-1999: reduced number of papers (6 articles); 2) 2000-2009: an increase in the number of published articles (32 articles), and 3) 2010-2019: a large number of published works (222 articles). Overall, approximately 59% of the articles were published during 2015-2019, simultaneously with the establishment of different global strategies such as the Millennium Development Goals (MDGs) settled in 2000 for the subsequent 15 years (United Nations, 2015b), and the UN SDGs established in 2015 (United Nations, 2015a). These international strategies highlighted the challenges that need to be addressed by humanity. In particular, the SDGs consider a comprehensive approach, involving poverty, hunger, prosperity, environment, climate, peace, and justice (Griggs et al., 2013), paving the road towards a more sustainable world to meet the needs of the current generation without compromising the needs of future generations (United Nations, 2015a). The majority of the articles were published in Asia (96 articles) and Africa (52 articles). Developed regions in America, Europe, and Oceania received less attention than Africa and Asia with 45, 38 and 7 published articles, respectively. Besides, 31 articles were focused on the global scale. Some articles focused on more than one region (Fig. 3).

The 260 selected articles cover six principal research fields (Fig. 4). Three research fields become more preeminent during the 1990s: 1) *efficiency of agricultural systems*, 2) *urban and peri-urban agriculture movement*, and 3) *effect of climate change in agriculture*. During the first decade of the 21st century, the other research fields started to be more attractive. Overall, more than 77% of the articles were published between 2010 and 2019.

Most of the articles were included in the field of *efficiency of agricultural systems (50%), dynamics of agricultural land systems*, *land suitability for agriculture*, and *farmer's motivations and decisions in agriculture* were conducted in Asia (50%, 34%, 35%, 33%, respectively) and Africa (15%, 24%, 18%, 33%, respectively) (Fig. 5). Southeast Asia and Subsarian Africa are the areas of the globe where hunger is an alarming problem (Alexandratos and Bruinsma, 2012), although cropland area (100

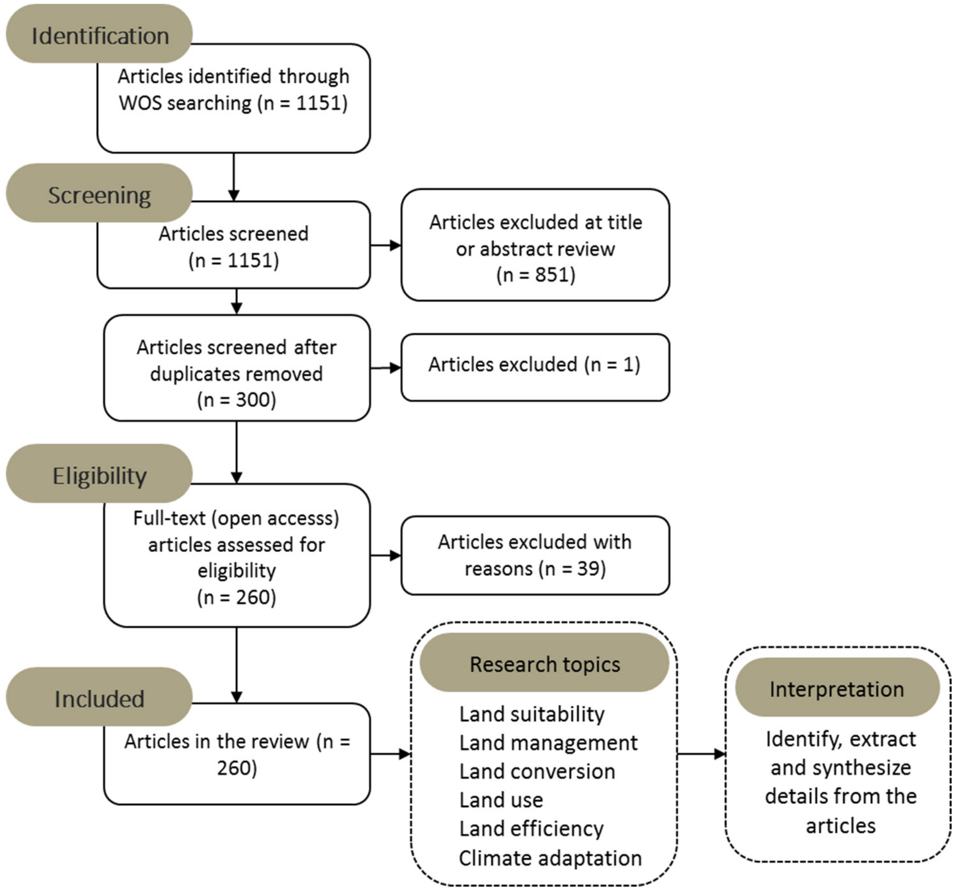

Fig. 1. Systematic review framework based on PRISMA protocol and inductive approach.

million ha in Asia and 59 in Africa) (OECD/FAO, 2009) and the foreign investment (Mason-D'Croz et al., 2019) increased substantially. In these regions, poverty, population and urbanization growth rates, climate change effects, vulnerability to extreme events, and food insecurity are much higher than elsewhere in the world (FAO et al., 2020; United Nations, 2019). Moreover, these are also the regions where land degradation is a serious problem (Millennium Ecosystem Assessment, 2005). Therefore, most of the efforts should be conducted in Southeast Asia and Subsarian Africa to increase the capacity of these regions to achieve the SDGs (FAO, 2021; FAO et al., 2020).

The *Urban and peri-urban agriculture movement* research field was mainly carried out in (North) America (28%), Asia (24%) and Africa (24%). Urbanization in Northern America is not a new phenomenon, and 82% of people live in urban areas (2018) (United Nations, 2019).

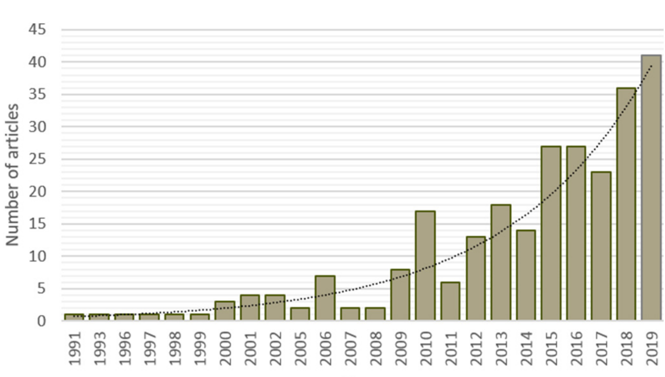

Fig. 2. Number of articles published by year.

For instance, in the United States, there has been an increasing interest from different institutions (e.g., academic, civic) in urban agriculture issues in the last decade (Siegner et al., 2018). Therefore, this increased the research carried out. In Africa and Asia, urbanization is recent due to the massive rural exodus (United Nations, 2019). In this context, it is important to study the impacts of cities growth on land consumption and how this can affect food security in the following decades (United Nations, 2019; World Bank Group, 2015). Therefore, it is not surprising that many of the selected works are in Africa and Asia. The articles focused on *climate change's impact on agriculture* were mainly developed globally (27%) and in Asia (25%). Climate change is a global issue, irrespective of the geographic area. Therefore, the importance of international studies is high (e.g., Van Meijl et al., 2018). On the other hand, some areas are more affected than others, and the impacts are unequal (FAO et al., 2020). One of these areas is Asia, where the poverty rate and population density is high (e.g., Southeast Asia), exacerbating the impacts of climate change on agriculture (e.g., Im et al., 2017). Therefore, it was rather expected that a substantial number of the selected works were carried out in this continent. The challenges to achieving food security and the SDGs are aggravated by the vulnerability to climate change, mainly because it affects the most vulnerable and have a highly heterogeneous pattern (FAO, 2020; IPCC, 2014; Schmidhuber and Tubiello, 2007). Ensure global food security is a tremendous global challenge (FAO, 2021; FAO et al., 2020; World Bank Group, 2015). While most of the selected articles were conducted on developing regions in Asia and Africa, further studies are needed in areas with different realities where food security has improved substantially but still can be affected by climate change. For each research field, a differentiated cross-timescale analysis should be prioritized to help to face the challenges outlined by the SDGs (World Bank Group, 2015).

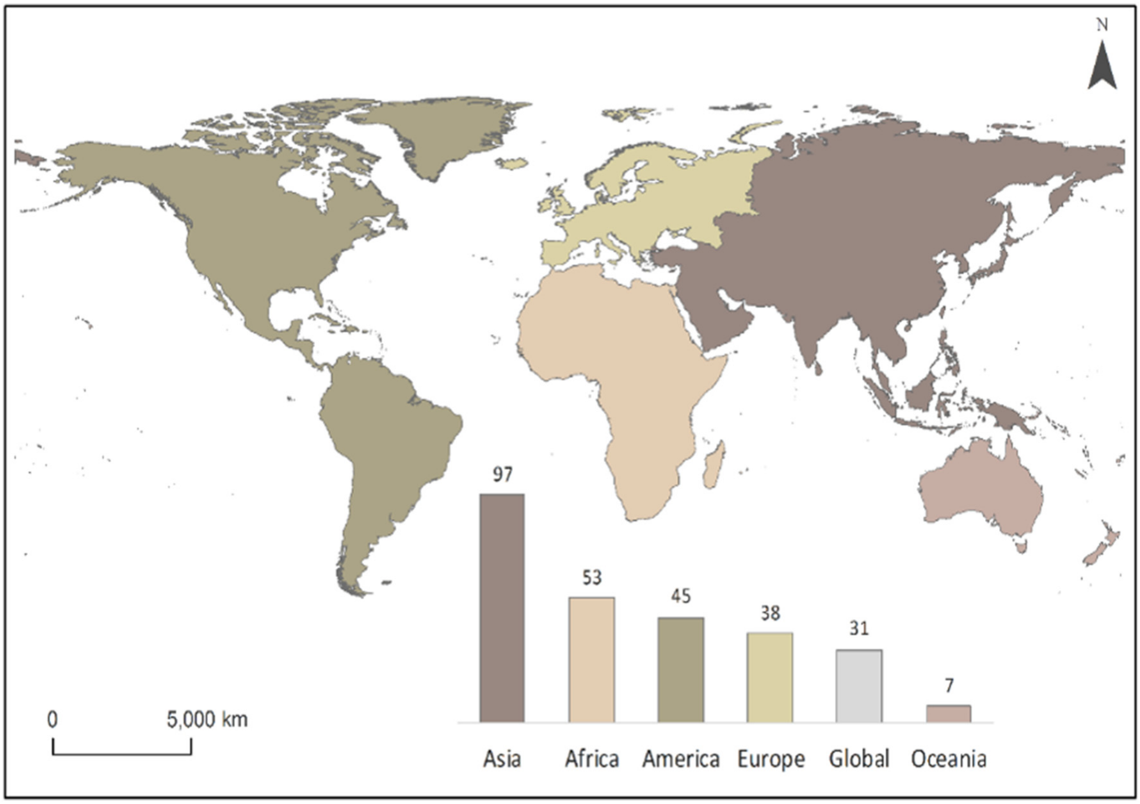

Fig. 3. Geographic coverage of the article case study.

3.2. Main research fields from an agricultural land system perspective

3.2.1. Dynamics of agricultural land system

The *dynamics of the agricultural land system* was the research field with the highest number of published articles (28%). Several works were developed to detect, characterize, monitor, map, and model agricultural land. There were two main methodological directions:

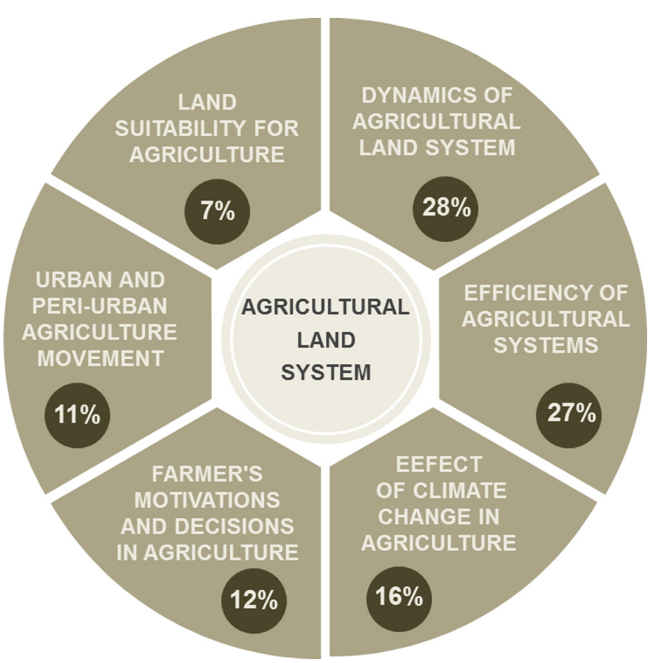

Fig. 4. Synthesis of the research fields and percentage of articles per field.

1) Spatiotemporal expansion or contraction of agricultural land areas in different periods and geographic contexts (e.g., Cao et al., 2019; Kühling et al., 2016; Nakalembe et al., 2017). Several driving forces and processes, acting individually or coupled affect agricultural land-use changes, were identified and analyzed in the context of different scenarios. They are mainly related to the functioning of local and national financial markets, demographic trends, environmental factors, and internal and external policies (Eklund et al., 2017; Garrett et al., 2018; Piquer-Rodríguez et al., 2018). These drivers are incorporated in different land-use models (e.g., SLEUTH, cellular automata, Markov chains) to simulate spatiotemporal land changes and forecast future agricultural land changes (e.g., Grundy et al., 2016; Martellozzo et al., 2018) and 2) Mapping and/or monitoring agricultural land at different temporal and spatial scales (e.g., Piiroinen et al., 2015; Torbick et al., 2017). For instance, by compile and analyze real-time data and using multitemporal and multisensor methodologies, several articles studied the crops phenophase, crop nitrogen stress, the cropland rotation and diversity, and the crop yields (e.g., Monteleone et al., 2018; Samasse et al., 2018; Veloso et al., 2017). Overall, by combining geographic information systems (GIS) and the use of different data types (e.g., remote sensing data products, historical and statistical data), the dynamics of agricultural land is simulated in both the past, present, and the future at regional, national, and global scales (e.g., Grundy et al., 2016; Shi et al., 2016; Torbick et al., 2017).

3.2.2. The efficiency of agricultural systems

The *efficiency of agricultural systems* was the second field of research, with more articles selected (27%). Different factors (e.g., human and environmental) on agricultural land productivity and food production received important research attention. Three measures are generally mentioned in the literature: 1) agricultural production (the net produce or output of cropland), 2) agricultural crop yield (the amount of crop harvested per unit area of land), and 3) agricultural productivity (income produced per unit area of land or person employed, i.e. the

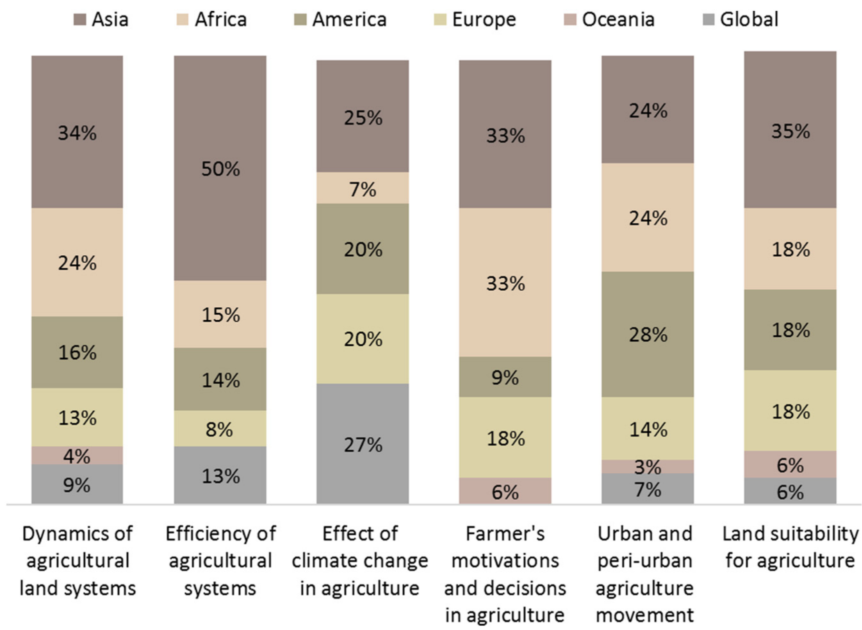

Fig. 5. Location of the article case study per research field.

market value of the final output) (Lin and Hülsbergen, 2017; Shen et al., 2013). Agricultural efficiency and productivity have been synonymously and interchangeably used. This is explained by the fact that agricultural productivity ((measured in terms of the amount of output (referred to as yield) per unit of area of input)) refers to the productive efficiency sector of the total agricultural efficacy. Thus, agricultural productivity is a part of agricultural efficiency, a broader concept expressed in crop productivity levels per unit area or other inputs or nutrition provided per unit area yield. These measures are used to assess the positive or negative influence of operational and structural factors in agricultural land production at different scales (e.g., Jin et al., 2017). Through various methods such as econometric analysis, crop model simulations, and non-parametric techniques (e.g., Van Ittersum et al., 2013), using aggregated (at the national or global level) or disaggregated data (at regional level), a wide range of environmental, institutional, organizational, managemental, and socioeconomic factors, are put in perspective to clarify their influence on productive efficiency (e.g., Hong et al., 2019; Mbata, 2001). Environmental and human factors such as water availability (e.g., Yan et al., 2015), land degradation and land fragmentation (e.g., Looga et al., 2018), terrain slope (e.g., Li et al., 2014), pest pressure (e.g., Drechsler et al., 2016) are often considered. Likewise, the influence of agricultural practices innovations adoption, from land consolidation (e.g., Hong et al., 2019), (bio) fertilizer applications (e.g., Nayak et al., 2019), herbicide/pesticide applications (e.g., Schreinemachers and Tipraqsa, 2012), conventional tillage (e.g., Das et al., 2014), are also being measured.

3.2.3. Effect of climate change in agriculture

Sixteen % of the articles selected were focused on the *effect of climate change in agriculture*. Briefly, several works evaluated short and long-term changes in the climatic conditions and their consequences on agricultural systems, considering different model's techniques (e.g., Leng and Hall, 2019; Manners and van Etten, 2018; Yu et al., 2012). The influence of individual factors within these scenario sets was used to forecast the geographic distribution of crop yield and agricultural productivity gains and losses in several world regions (e.g., Europe, Africa and Asia). In addition, the definition of scenarios identify the existing relationship between the factors associated with the climate change impacts on agricultural land systems and simulate the effect of future scenarios considering different future narratives (e.g., Ahmed et al., 2016). Overall, the methods applied biophysical and agro-ecosystem process-based models and statistical simulation models to estimate agricultural yields at different scales and climate change scenarios (e.g., Basso et al., 2015). Process-based models simulate crop growth processes, according to different climate factors, such as temperature or rainfall variations, and extreme upward events (particularly floods and droughts) (e.g., Kukal and Irmak, 2018; Leng and Hall, 2019), or soil properties and management (e.g., Basso et al., 2015). Statistical models estimate future trends in agricultural yields (e.g., by changes in temperature, CO_2, or fertilization) based on statistical correlations from historical trends (e.g., Mori et al., 2010).

3.2.4. Farmer's motivations and decisions in agriculture

The *farmer's motivations and decisions in agriculture* were studied by 12% of the works selected. Farmers' land-use decisions and their management strategies and motivations are often conditioned by agro-ecological, climatic, and political conditions, influencing local practices (e.g., Brady et al., 2012; Kvakkestad et al., 2015). Farmers' motivations depend on what they consider advantageous. They can minimize the risk of losses (e.g., which food crops to grow, the fallow period duration) or management decisions (e.g., fertilizers/pesticides input, mechanization, tillage, or irrigation) (e.g., TerAvest et al., 2019; Yang et al., 2017). Other articles were focused on the farmers' decisions regarding their choices towards uncertain factors that affect the agricultural productivity and farm food self-sufficiency (e.g., agricultural policy reform, government incentive/subsidy programs) (e.g., Brady et al., 2012; Chibwana et al., 2012), or others externalities (e.g., pest, plant disease, technology, soil contaminants, weather variability, or land tenure agreements) (e.g., Boz, 2016; Nkomoki et al., 2018). Furthermore, the different management options and the socioeconomic factors were analyzed at the farm level, i.e., as experimentation, to understand how the farm revenue or the crop yield is impacted depending by the practices adopted (e.g., Leonardo et al., 2015; Lin and Hülsbergen, 2017; Vasile et al., 2015). The constraints or opportunities of the farmland production situations were assessed through surveys or group discussions at the household/field level (e.g., Hao et al., 2015; Leonardo et al., 2015). In some cases, spatial and/or statistical data were included (e.g., Gunda et al., 2017; Lyle et al., 2015).

3.2.5. Urban and peri-urban agriculture movement

The urban and peri-urban agriculture movement was studied by 11% of the articles selected. Urban and peri-urban agriculture is a popular topic worldwide (Cerrada-Serra et al., 2018; Li et al., 2019; Mackay, 2018). Depending on the research objectives, urban agriculture (UA) or peri-urban agriculture (PUA) are studied individually, while others are integrated (Urban and Peri-urban agriculture - UPA). UPA is a multidimensional concept since it covers different production techniques (e.g., aquaponics, hydroponics, permaculture productions, food crops and livestock) and purposes (e.g., pedagogy, consumption, farmers markets) in different locations (rooftops, communal or private gardens) and scales (Mougeot, 2011; UNDP, 1996). UPA consider subjects such as access to food, health, income, the environment or natural resources (Tornaghi, 2014). Overall, there are three essential approaches. 1) Governance and policies, i.e., articulation between urbanism, land-use planning and agriculture preservation in the urban and peri-urban areas (e.g., She et al., 2015). There are several issues related to land use conflicts and governance challenges. For example, 1) in the access to land that can be public or private, or in the form of organization that may be more spontaneous or more institutional (e.g. community gardens) (e.g., Ayambire et al., 2019; Cerrada-Serra et al., 2018); 2) Locate vacant, abandoned, or marginal land within a city or on its periphery to use it for agriculture practice (e.g., Pothukuchi, 2018; Saha and Eckelman, 2017) and 3) Identification of patterns and trends in agriculture land uses affected by rapid urban expansion (e.g., Li et al., 2019; Yu et al., 2018).

3.2.6. Land suitability for agriculture

Seven % of the papers selected focused on *assessing land suitability for agriculture*. These articles mainly focused on identifying suitable areas for agriculture use (e.g., Mesgaran et al., 2017; Musakwa, 2018) and producing specific agricultural food-grain crops (e.g., Boix and Zinck, 2008; Kazemi et al., 2016). The approaches used in this research field were focused on spatial analytical methods to identify the multiple factors that affect the suitability of the land (e.g., topography, soil properties, climatic characteristics, socioeconomic drivers) (e.g., Kazemi et al., 2016; Schiefer et al., 2016; Zabel et al., 2014). Usually, the weight of the variables is assessed using an expert's evaluation. Frequently, multi-criteria evaluation (MCE) methods (e.g., Musakwa, 2018) were applied, such as the analytic hierarchy process (AHP) (e.g., Geng et al., 2019), fuzzy logic (e.g., Zabel et al., 2014), and weighted linear combination (WLC) (e.g., Li et al., 2017; Montgomery et al., 2016). For instance, two or more methods can be combined. Overall, the output of the analysis is an agricultural land suitability map that commonly presents four categories (not suitable, marginally suitable, moderately suitable, and highly suitable) according to the land suitability index of the FAO (e.g., Geng et al., 2019; Mendas and Delali, 2012).

3.3. Insights towards “a better and more sustainable future for all”

Boosting agricultural production and productivity of agricultural land currently under production is a recognized strategy to enhance and maintain food supply and reduce hunger (Millennium Ecosystem Assessment, 2005; The Royal Society, 2009; Wu et al., 2014). The *efficiency of the agricultural systems* is a relevant field of research, where the influence of different factors on agricultural land productivity is evaluated to meet food needs (e.g., Hong et al., 2019; Mbata, 2001). Moreover, the progress in this field of research will contribute directly to SDG 2 (Zero hunger) and SDG 1 (No Poverty). As shown in World Bank Group (2015) report, an increase of 1% in food production reduce 0.48% and 0.72% of the poverty in South Asia and sub-Saharan Africa. In addition, the increase in agricultural efficiency of the main crops could substantially increase farmers' income and stimulates domestic trade in the countries (SDG 8 - Decent Work and Economic Growth) and promote good health and wellbeing (SDG 3 - Good Health and Well-being) (World Bank Group, 2015). It is necessary to incorporate different factors (e.g., environmental, institutional, organizational, and socioeconomic) to have a more e efficient agricultural management and reduce the impact on ecosystem services (FAO, 2011; Millennium Ecosystem Assessment, 2005). For instance, factors such as pests and pathogens are estimated to be responsible for reducing about 35% of crop yields (Oerke, 2006; Popp et al., 2013). This may influence the progress towards the achievement of SDG 2. Expanding genetically modified crops (Van Hesse et al., 2020) or applying organic pesticides (Kalkura et al., 2021) could be viable solutions for decreasing crop yield losses associated with pests diseases. Nevertheless, the use of genetically modified plants can raise concerns regarding human health and biodiversity loss (e.g., Raman, 2017; Tsatsakis et al., 2017). In addition, there are several shreds of evidence that herbicide-resistant crops do not provide better yields or decrease the application of herbicides. The investment in herbicide-resistant crops and the use of herbicides had several detrimental effects such as 1) decreased crop rotation and increased weed management based on herbicides; 2) the application of glyphosate-based herbicides affect soil microbiology and plant diseases resistance and 3) the use and abuse of glyphosate in the last 20 years increased the appearance of 34 glyphosate-resistant weed species (Schütte et al., 2017). The application of pesticides and herbicides in agriculture have been linked to the emergence of several chronical (e.g., diabetes, asthma, cancer) and other short-term diseases (e.g., headaches, dizziness, nausea, skin and eye irritation) (Kim et al., 2017; Brevik et al., 2020). Also, climate change and biodiversity loss increase pest and disease frequency, as highlighted in previous works (e.g., Anderson et al., 2004; Potter and Urquhart, 2017; Rosenzweig et al., 2001). Overall, the efforts carried out to increase food security and improve SDG 2 may be detrimental to the achievement of another (e.g., SDG 3 – good health and wellbeing; SDG 15 - life on land) (OECD, 2020; United Nations, 2015a).

Likewise, providing information on available and suitable land for agricultural production can contribute to the identification of the best areas for crop production, establish a sustainable intensification and maximize food production (EEA, 2017; Shen et al., 2013; Struik and Kuyper, 2017; Wu et al., 2014), which is in line with the SDG 2. Therefore, *land suitability for the agriculture* field of research is very relevant from a land management perspective (Akpoti et al., 2019), promoting proper, efficient, rational land use. This is highly relevant to the achievement of SDG 1 (no poverty), SDG 2 (zero hunger), SDG 6 (clean water and Sanitation), SDG 11 (sustainable cities and communities), SDG 12 (responsible consumption and production), SDG 13 (climate action), SDG 14 (life below water) and SDG 15 (life on land) (Akpoti et al., 2019). From this perspective, assessing the land potentially can also be an effective strategy to implement sustainable agriculture (OECD, 2020), which would strengthen population health (SDG 3-good wealth and wellbeing) (Li et al., 2017).

Agriculture covers approximately 38% of the land surface. However, in some areas (e.g., urban and peri-urban areas), food security is decreasing (Foley et al., 2011; Godfray et al., 2010; Grundy et al., 2016; Radwan et al., 2019). Therefore, evaluate the changes in agricultural lands, and the drivers responsible for such changes are the motivation of the *dynamics of the agricultural land* field of research. The agriculture spatiotemporal changes will support food production and safety policy decisions, in line with SDG 2 (Sun et al., 2018; van Vliet et al., 2015; Viana and Rocha, 2020). Moreover, spatially and temporally accurate information contributes to effective land management, which is a key towards sustainable land use (OECD, 2020) and important for meeting SDG 6, SDG 7 (transitioning to clean energy), SDG 13 (Kasperson and Kasperson, 2001; Ogle et al., 2017; Tyson et al., 2001), and improve the ecosystems (SDG 15) (Weiss et al., 2020).

Meeting global food supply demand for a growing population (FAO, 2017) is one of the 21st-century challenges that will be exacerbated by climate change (FAO, 2020; IPCC, 2014). Moreover, the areas threatened by climate change and high population growth are located in the same geographical area (Sub-Saharan Africa and Southeast Asia) (Alexandratos and Bruinsma, 2012; United Nations, 2019). Despite technological progress, food production will be negatively affected by the changing climate patterns and increases in the frequency and intensity of extreme weather events (Abd-Elmabod et al., 2020; IPCC, 2014).

Therefore, the *effect of climate change in the agriculture* field is key to develop essential knowledge to forecast agricultural production under different climate scenarios (Abd-Elmabod et al., 2020; Fanzo et al., 2018; Leng and Hall, 2019) and improve food safety, better health, and strengthen resilience to climate variability (SDGs 2, 3 and 13), as well as improve the ecosystems (SDG 15) (Arora, 2019).

The production of food is also developed outside the rural areas. The research focused on this topic is timely. Since 2018, more than half of the human population has lived in urban environments, and by 2050 this proportion is expected to increase to 68% (United Nations, 2019). As *the urban and peri-urban agriculture movement* field of research suggests, agriculture in urban and peri-urban contexts is a global trend that has been enforced as a strategy to combat climate change (SDG 13), increase food security (SDG 2) and make the urban areas more liveable (SDG 11) (Brevik et al., 2020; Ferreira et al., 2018; Opitz et al., 2016). Agricultural activities in urban and peri-urban areas have many benefits (Lin et al., 2015; Saha and Eckelman, 2017). Contributes to meet the nutritional needs by providing access to fresh and healthy food products (SDG 2), improve human health and wellbeing (SDG 3) (Aubry et al., 2012; Santo et al., 2016), generates local food economies contributing to poverty alleviation (SDG 1) (Lwasa et al., 2015); and promotes local educational (SDG 4 – quality education) (Eigenbrod and Gruda, 2015). Moreover, urban and peri-urban agriculture have relevant ecological and social functions in air quality regulation, soil erosion regulation, floods regulation, increase the population accessibility to green spaces, and promote efficient water management (SDGs 6, 11, and 15) (Ayambire et al., 2019), increasing the sustainability of the urban areas (Sioen et al., 2018; Tsuchiya et al., 2015; Zezza and Tasciotti, 2010).

The response to our right to food and security depends on the interests and motivations of local land use decision-makers. While the government put policies and design incentives to induce changes in individuals' behavior, the farmer manages the farm according to their interests (Foguesatto et al., 2020). The *farmer's motivations and decisions in agriculture* is a very relevant field of research since it puts in perspective the farmers' management decisions (Malek et al., 2019) and supports SDGs. Specifically, it will contribute to improving the income and livelihood levels of farmers reducing rural poverty (SDGs 1 and 8) or enhance the local and regional food production needs (SDG 2) (FAO, 2020; World Bank Group, 2015). In addition, more informed decisions can be taken to evaluate food system vulnerability, reduce the impacts on climate factors (SDG 13), and foster sustainable agricultural practices and natural resources exploitation (SDGs 6 and 12) (FAO, 2020; United Nations, 2015a).

3.4. The tradeoffs dilemma

For the coming decades, agricultural areas need to double the food production to ensure a stable and accessible food supply (Foley et al., 2011; Tomlinson, 2013). However, the current agri-food systems (e.g., agricultural practices, food preferences and consumption shifts) are increasing greenhouse gases emissions and ecosystems degradation (e.g., soil degradation, loss of biodiversity, water scarcity) (Goucher et al., 2017; Pereira et al., 2018b; Sánchez-Bayo and Wyckhuys, 2019; Zuo et al., 2018). This agriculture expansion and the associated impacts (e.g., greenhouse gases emissions and ecosystems degradation) are evident in areas near the sub-tropical and tropical forests (e.g., Amazon) (Aizen et al., 2019; Montelles et al., 2021). The tradeoffs associated with agriculture may cause a global crisis in food security or environmental degradation at an unprecedented scale (Michel-Villarreal et al., 2019; Yang et al., 2020). As a result, any progress achieved in food security and SDG 2 may not represent an increase in the sustainable environment because it can be very detrimental to the environment (Foley et al., 2011; Marsden and Morley, 2015; Scherer et al., 2018; World Bank Group, 2015). Therefore, important decisions must be made to minimize the tradeoff between increasing food production and reducing greenhouse gas emissions and biodiversity loss from agriculture (FAO, 2017; FAO et al., 2020; Foley et al., 2011; United Nations, 2019). This is a challenge faced by the agri-food sector since a reduction in food system greenhouse gas emissions, water use, biodiversity loss, and soil degradation is key to decrease the agriculture footprint (EEA, 2017; Foley et al., 2011; United Nations, 2019; van de Kamp et al., 2018). The wide implementation of well-known solutions is needed such as reduce food waste (e.g., Rosenzweig et al., 2020), water reuse (e.g., Ricart and Rico, 2019), agriculture intensification (e.g., tillage, pesticides and herbicides use) (e.g., Faiz-ul Islam et al., 2020; Sattler et al., 2020), meat consumption (Stoll-Kleemann and Schmidt, 2017) and invest in sustainable practices based on no-tillage (e.g., Dachraoui and Sombrero, 2020), crop diversification, use of organic fertilizers, increase rotation periods and cover cropping (e.g., Feng et al., 2018) that are beneficial to increase the crop resilience to pests (e.g., Murrell, 2017) and can increase yield, as observed in several works (e.g., Huang et al., 2018; Beillouin et al., 2019; Jat et al., 2019). In addition, more efforts are needed to increase food quality, a target that can be achieved using sustainable agriculture practices (e.g., Lampridi et al., 2019; Michel-Villarreal et al., 2019; Zulfiqar et al., 2019).

Nevertheless, the concept of sustainable development is multidimensional in time and space and is achieved if there is socioeconomic development and environmental protection (Allen and Prosperi, 2016). Remarkably, the solutions to the long-term sustainability and food supply require adopting sustainable agricultural practices as an effective strategy with reduced environmental impact (Allen and Prosperi, 2016; EEA, 2017; Wu et al., 2014). It is essential to promote local, diverse, and sustainable agriculture that respects the environment and understanding international trade as a complement to local production. The local and national systems need to be strengthened to adapt to the climate crisis and diversify the farmed products. Crop diversity can reduce crop vulnerability to pests and diseases risks, open markets for different food crops, break their dependence on commercial crops, increase biodiversity, and reduce the impacts on climate change (The Royal Society, 2009). In addition, the success of agricultural transformation depends mainly on smallholders' capacity to adopt sustainable practices and adapt to climate change (FAO, 2017; Li et al., 2020). All in all, the effectiveness of research, policies, planning, and investment to build a resilient agricultural system and increase food production depends on local and global challenges and how they mitigate the tradeoffs caused by food production (The Royal Society, 2009).

3.5. Geospatial data, spatial analysis, integrated models, and interdisciplinary research

Agricultural land systems depend on different environmental and socioeconomic factors that interact in space and time (Scown et al., 2019; Stephens et al., 2018). Therefore, it is a dynamic and complex social-ecological system and a top research priority for global development and sustainability (Allen and Prosperi, 2016; Müller et al., 2020; Yu et al., 2012). Therefore, agricultural land systems research needs an interdisciplinary approach and incorporates different science branches (Ingram et al., 2020; Ruben et al., 2018; Scown et al., 2019; Yu et al., 2012) at different temporal and spatial scales (Yu et al., 2020).

From this literature review, it is clear that research and innovation activities, coupled with systemic theories, multitemporal and multisensory technologies, GIS techniques, scenario development and analysis, land-use models, agricultural economic/trade modeling, and geospatial data, are essential to address several SDG's challenges (Avtar et al., 2020; Müller et al., 2020; Weiss et al., 2020). For instance, many SDG targets are related to geoinformation (Avtar et al., 2020; Yuan, 2021). Specifically, data availability, timely, spatially, and accurately, is crucial to monitoring SDGs achievement in different countries (United Nations, 2012, 2015a). In addition, long-term databases are helpful to improve both climate-change and land-change models or establish more informed baselines for the different scientific disciplines, particularly those involving food security (Boivin and Crowther, 2021; World Bank Group, 2015). Also, the improvements in data collection, methodological advances, and robust models are essential to improve the current knowledge and likely open new questions that need to be addressed in different geographical and temporal contexts.

3.6. Limitations of this systematic review

The literature review is limited to WOS articles. Grey literature (e.g., reports) was discarded because we only want to review peer-reviewed articles in indexed journals to ensure quality control and scientific credibility. Likewise, the screening procedure involved synthesizing the information contained in the articles, which has undoubtedly led to generalization, and some information might be underestimated. It should be noted that it was outside of the article scope to analyze individual articles' theoretical and methodological approaches. Therefore, a vital implication of this study is that there has been no critical analysis of the methodologies applied in the different publications. Moreover, the empirical identification of research fields was based on the adaptation of six broad research topics from Yu et al. (2012) and Wu et al. (2014) works and the author's academic background, meaning there is always room for further improvement. The number of papers per continent may be related to the country's investment in R&D. Despite the limitations; this work provides important insights regarding the current state of knowledge of food security and their relation with the different SDG's.

4. Conclusions

This paper presented a systematic literature review, describing the main research fields in agricultural land systems and their linkage with the SDGs. Our analysis revealed that most articles were published during 2015-2019 (59%), with the case studies focused mainly on developing regions in Asia (36%) and Africa (20%). In the last 30 years, the body of research has been centred in six main research fields in the subjects of land-use changes (28%), agricultural efficiency (27%), climate change (16%), farmer's motivation (12%), urban and peri-urban agriculture (11%), and land suitability (7%). Each research field is diversified and highly important for long-term global development, providing approaches with different cross-scale frameworks and geographical contexts. The six areas are directly or indirectly linked to 11 of the 17 SDGs. However, the discrepancy in the percentage of publications by research field emphasizes the need for future studies to fulfil this gap because each domain has a vital role in providing knowledge to food security and the SDGs. In this context, more studies are needed in the different geographic areas and research fields, and this can be improved by using new datasets, methodological approaches and robust models.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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