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RISK MANAGEMENT TOOLS IN THE AGRICULTURE SECTOR: AN UPDATED BIBLIOMETRIC MAPPING ANALYSIS

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ABSTRACT

PURPOSE: The aim of this paper is to analyse the latest research carried out to identify the risk management tools that farmers should possess to be effective and achieve success in their businesses. To this end, a review of the literature was conducted through the most relevant subjects, categories, countries, journals, and cited authors and articles, as well as visualising the interrelations through the co-occurrence of key terms.

DESIGN/METHOD: A systematic review of the literature and a bibliometric mapping of the publications indexed in the Web of Science Core Collection (WoSCC) and Scopus was conducted using VOSviewer software. During the search process, 472 references from WoSCC and 704 from Scopus databases, for a search period from 2014 to 2023, were obtained. After a thorough reviewing process, the final number was 100 articles collected in 74 journals and written by 320 authors for WoSCC; and 136 articles, 90 journals and 435 authors for Scopus.

RESULTS/FINDINGS: Our study indicates that farmers' risk management requires the acquisition of knowledge of risk management tools, specifically differentiating between on-farm and off-farm instruments, and the training competences necessary for their implementation which are acquired both through their business management and others developed during the work in the crops, farming and agroindustry. Based on co-occurrence frequencies of key terms, several term maps provide visual representations of the latest research in the Agricultural Risk Management Tools (ARMT) and, more specifically, of the grouping around five main clusters, namely Strategy Decisions on Adaptation to Climate Change, Risk Impacts on Agricultural Production, Attitudes towards Risk Management Tools, Agricultural Policy and Risk Management, and Farms Management Systems and Models.

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ORIGINALITY/VALUE: This study contributes to the literature on risk management research and its findings may be useful for farmers, farm managers, agricultural cooperatives, researchers, and decision-makers in agricultural policy.

KEYWORDS: risk management tools, agriculture, Common Agricultural Policy (CAP), Income Stabilisation Tool (IST), bibliometric mapping, VOSviewer.

JEL: G52, O13, O16, Q12, Q56.

1. INTRODUCTION

Risks in agriculture stem from various sources and there are several risk management options that can be used to mitigate, transfer or cope with them in agriculture. Several factors influence the choice of the most appropriate tool, such as the type of risk, the availability of tools and the level of responsibility (FAO elearning Academy, 2023).

Farmers can manage production, market and financial risks and uncertainties using a variety of tools and strategies. Of the ten different typical types of risk that can be identified (compliance, legal, strategic, reputational, operational, human, security, financial, competitive, and physical), operational, financial and competitive risks are perhaps the ones that affect farmers the most. Agricultural Risk Management Tools (ARMT) aim to smooth out income swings for farmers. By lowering risk and uncertainty, these tools can help families build savings and invest in better farming practices. However, it is crucial to design these tools with local conditions in mind. They need to be flexible enough to address the specific needs and limitations of each country, community, and individual household (World Bank, 2005).

Farmers face extensive challenges in income loss due to multiple factors. The causes can be varied and are associated with poorer outcomes. European-level solutions such as the Income Stabilisation Tool (IST) are attracting global attention. However, despite the time elapsed, only one region in Italy has been able to implement it, despite several attempts in the Castilla-León and Andalusia regions in Spain.

The use of bibliometric analysis in this area of interest still needs to be identified. This study aims to analyse the overall trends and patterns of scientific publications related to agricultural risk management tools that can be used by farmers to better cover and run their farms. Therefore, the purpose of this paper is to conduct a systematic review of the literature and a bibliographic mapping of the latest research to identify the risk management tools that farmers should possess in order to be effective and achieve success in their business.

To accomplish the goals, an extensive search of terms related to this topic was conducted. The aim was to locate articles published in journals and other documents indexed in the Web of Science Core Collection (WoSCC) and Scopus databases. A bibliometric mapping of the publications indexed in WoS and Scopus in the last ten years was carried out using VOSviewer software. During the search process, 1,817 references from Web of Science Core Collection and 2,588 from Scopus databases were obtained for a search period from 2014 to 2023. The term map visually represents the latest research in the Agricultural Risk Management Tools (ARMT) based on the co-occurrence frequencies of authors and key terms. Thereby, this study is a contribution to the literature on Risk Management (RM) research and its findings can be helpful to farmers, farm managers, agricultural cooperatives, researchers, and decision-makers in agricultural policy.

The subsequent sections of the paper are structured as follows. Following this introduction, a review of prior studies and bibliometrics in this specific topic is carried out. The third section describes the dataset and the research methodology applied. The fourth section reports the main results obtained with the application of bibliometric mapping techniques using the VOSviewer software. Finally, the fifth section summarises the conclusions, implications and limitations.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

In a globalised and interconnected world full of uncertainty and instability, farmers face a myriad of risks, some of which they can eliminate, avoid, reduce or pay to others who are better prepared to bear them. However, there are other risk factors, such as the volatility of final product prices or input costs, the adverse effects of economic crises and recessions, the consequences of trade agreements with third countries, or environmental policy decisions, which only responsible policy makers in government agencies and institutions can eliminate or reduce. Therefore, in this section the contributions of different authors, whose conceptualisations, approaches, methodologies, and research findings, both from individual farmers and from governments, will be analysed, serving as a theoretical framework and prior research for this study.

2.1. Resilience and holistic approach to Agricultural Risk Management (ARM)

Several studies have examined how farmers manage the risks inherent in agriculture. OECD (2009a, 2009b) examines the types of agricultural risks and existing policies to manage them. Mitchell (2013) highlights the importance of building resilience as a practical strategy for farmers to cope with uncertainty. Spiegel et al. (2020) and Finger et al. (2022) agree, highlighting the need for innovative risk management approaches tailored to specific farms and systems. Grzelczak et al. (2023) explore the concept of resilience in agriculture in the face of increasing volatility, while Kalogiannidis et al. (2023) examine the linkages between agricultural risk, vulnerability, resilience and sustainable rural development. Overall, these studies recognise the diverse challenges faced by farmers and advocate a combination of risk management practices and resilience-building strategies to ensure a sustainable agricultural future.

Agricultural risks are complex and multifaceted, encompassing everything from weather and disease to market fluctuations and policy changes (OECD, 2009a). While ‘resilience’ has become a buzzword in development circles (Mitchell, 2013), it provides a valuable framework for understanding how farmers can adapt to these multiple challenges (Mitchell & Harris, 2012). A resilient farming system hinges on the ability of farms, communities and support structures to absorb shocks and continue to function (Meuwissen et al., 2019). This vulnerability is influenced by social and economic factors beyond the hazard itself (Marulanda et al., 2020). Collaboration and knowledge sharing are critical for farmers to navigate this complex risk landscape, and policy should support these efforts alongside technological advances (Finger et al., 2022; Slijper et al., 2020). Finally, building resilience requires a systematic approach to identifying and strengthening key capacities (Grzelczak et al., 2023).

Agricultural risk management (ARM) needs to be a comprehensive strategy that takes into account all the different risks farmers face and the different tools available (OECD, 2009a, 2009b). This ‘holistic’ approach recognises that risks, solutions and government policies are interconnected (Tedesco, 2018). It should also encompass the entire agricultural supply chain, from farm to consumer (Tedesco, 2018). Some argue that combining elements of resilience and traditional risk management is the most practical approach (Mitchell & Harris, 2012). Building resilience through ARM involves a variety of measures, including managing short-term shocks and addressing long-term challenges (Finger et al., 2022; Tochukwu, 2023). A diverse toolkit of risk management strategies is critical for farmers to manage uncertainty and prepare for the future (Finger et al., 2022). However, there is a need for better ways to measure the effectiveness of these strategies, particularly in terms of farm resilience (Grzelczak et al., 2023).

A two-pronged approach is key to agricultural sustainability: risk management (ARM) and resilience (OECD, 2009a). Strong ARM practices not only mitigate shocks but also build resilience, while understanding a farm's resilience helps to design better ARM strategies (Meuwissen et al., 2019). Several studies emphasise the importance of a holistic approach that considers not only physical risks, but also social, economic and financial factors (Marulanda et al., 2020). Research shows that a diverse toolkit of risk management strategies is associated with higher perceived resilience, particularly adaptability and transformability (Slijper et al., 2020; Finger et al., 2022). Collaboration and knowledge sharing are critical aspects of farm resilience, and future ARM strategies should focus on long-term challenges rather than short-term solutions (Slijper et al., 2020; Finger et al., 2022). There is a need for further research on financial resilience in agriculture, as financial vulnerability significantly hinders rural development (Grzelczak et al., 2023; Kalogiannidis et al., 2023).

ARM is a complicated but critical process for farmers' success (World Bank, 2016; Huirne et al., 2000). As it has been evidenced, it requires a holistic approach that considers all stakeholders, potential risks and available strategies (World Bank, 2016). These risks can be broadly categorised into production risks, market risks, and broader environmental risks (World Bank, 2016). Effective ARM involves both proactive measures to prevent adverse events and reactive measures to minimise their impact (Kahan, 2008). While there are costs associated with implementing ARM strategies, neglecting risk management can have serious consequences for farmers' livelihoods, market stability and even food security (Schaffnit-Chatterjee, 2010). The increasing complexity of agricultural risks due to globalisation, trade and climate change requires continuous adaptation of ARM practices (Duong et al., 2019).

2.2. Agricultural Risk Management Tools (ARMT)

ARM is a complex system with many interacting parts (OECD, 2009b). Traditionally, it is seen as a linear process of identifying risks, choosing tools and implementing government policies. However, a more nuanced view recognises the interconnectedness of these elements. Risks, tools and policies all influence each other, and the optimal approach depends on the specific farmer's situation and the broader agricultural context (Tedesco, 2018; Tochukwu, 2023). While 'resilience' offers a broader perspective on managing uncertainty, risk management, with its familiar concepts, remains a valuable framework for practical action (Mitchell & Harris, 2012).

Over time, a range of strategies have been developed to bear and manage all kinds of risks. Farm risk is related to losses arising from imperfectly predictable biological, climatic and price variables. Such factors may include natural adversities (e.g. pests and diseases), climatic factors beyond farmer's control, and adverse changes in input and output prices. For instance, high variability of production outcomes (production risk), price volatility and/or bad supply and demand conditions (market risks), high borrowing cost and/or lack of access to credit (financial risks), unexpected regulatory changes affecting producers' activities as more restrictive sanitary and phytosanitary standards (SPS) and/or changes in import/export regimes (institutional risks), etc. Kahan (2008), in addition to the above risks, attaches technological and equipment risks to production risks, and also points out other sources of risks in farming such as human and personal risks, as well as the frequent interrelation among all of them. For their part, Duong et al. (2019) categorise seven categories of risk: (i) the five most frequently cited in the literature (production risk, human risk, financial risk, output price and market risk, and institutional risk) and (ii) breaking down production risk into a sixth category, known as weather and climate change risk, and a seventh category, related to threats to biosecurity (i.e. outbreak of pest and disease or invasive species).

Designing effective risk management policies requires an understanding of how producers deal with risk. This includes recognising the difference between formal and informal strategies, as well as those implemented before (ex-ante) and after (ex-post) the occurrence of a risky event (World Bank, 2005).

Table 1 summarises the set of approaches collected in Kahan (2008), where they are explained with illustrative and practical examples of the use of each of them, highlighting their positive and negative aspects. Furthermore, the need to combine risk management strategies should also be emphasised, as although they are aimed at generating greater security in farming, covering one risk can often increase others, such as borrowing money or using agricultural derivatives contracts (forwards, futures and options).

Table 1. Risk management approaches by risk type

Types of risk	Management strategies
Production and technical risk	Risk-reducing inputs
	Risk-reducing technologies
	Selecting low-risk activities
	System flexibility
	Production diversification
	Reserves of inputs and produce
	Share leases
	Custom farming
Marketing Risk	Spreading sales
	Direct sales
	Contractual agreements to sell produce and buy inputs
	Forward pricing
	Building trust
	Market price information
Financial Risk	Access to borrowing credit
	Holding liquid assets
	Selling and leasing assets
	Managing the phasing of investments
	Contingencies
	Insurance
Institutional Risk	Traditional institutions and social arrangements
	Producer groups
	Cooperatives
Human and Personal Risk	Human resource management
	Labour planning
	Labour productivity

Source: Own compilation based on Kahan (2008).

Regarding the EU's risk management instruments, available before the reform of the new CAP model in 2013, through the use of the Income Stabilisation Tool (IST) and the Agricultural Mutual Funds, Schaffnit--Chatterjee (2010) collected various instruments, according to strategy type and provider (marked or government), and keeping in mind the interactions among them, their substitutability or complementarity (Table 2). Some of these instruments were widely used by EU government bodies in the implementation of its former CAP at a high budgetary cost.

For their part, Gunjal (2016) lists a wide range of potential tools for agricultural risk management (Table 3), providing a useful overview, including the function of each tool, its advantages and disadvantages, and its effectiveness in different risk scenarios.

Table 2. Farm risk management practices in Europe

Provider	Strategy		Instruments
Public risk management tools (Government mechanisms)	EU policies to stabilise markets and prices	Trade intervention measures	- Import tariffs - Export subsidies
		Price support	- Direct public intervention - Aid for private storage - Subsidies to promote internal consumption
		International market stabilisation policies	- Internationally managed stock-holding: potential relief in extreme cases
	Classical EU policies to cope with income instability		- Direct payments - Ad-hoc payments or calamity funds
	Payments for delivering public goods		- Benefits for environmental goods and services
Market-based risk management tools (Market mechanisms)	Hedging price risk with derivatives		- Forwards contracts - Futures contracts - Options contracts
	Agricultural insurance		- Single-risk insurance - Multiple-peril insurance - Whole-farm yield insurance - Revenue insurance - Income insurance - Index insurance contracts - Weather-index-based insurance
	Risk-sharing cooperatives		- Mutual stabilisation funds - Crop sharing - Vertical integration - Off-farm work - Off-farm income - Cooperation with other farmers

Source: Own elaboration based on Schaffnit-Chatterjee (2010).

Table 3. Agricultural Risk Management Tools (ARMT) by operational modalities

Modalities	Instruments	
On-Farm and Community Level Risk Management Tools	Tool 1	Climate Smart Agriculture (CSA)
	Tool 2	Crop and Enterprise Diversification
	Tool 3	Asset and Income Based Strategies
Finance Related Risk Management Tools	Tool 4	Agricultural Insurance
	Tool 5	Weather Index Insurance
	Tool 6	Agricultural Finance and Microfinance
Market Related Risk Management Tools	Tool 7	Contract Farming
	Tool 8	Commodity Exchanges and Futures Markets
	Tool 9	Warehouse Receipts Systems (WRS)
Government-Based Agricultural Risk Management Tools	Tool 10	Public Foodgrain Reserves
	Tool 11	Disaster Assistance Programs
	Tool 12	Social Protection and Productive Safety Nets

Source: Own compilation based on Gunjal (2016).

A further addition to the discussion on the taxonomy of risk management tools/methods is the ISO/COSO framework. In this regard, Kumar (2022) and Cobb (2023) analyse the strengths and weaknesses of the COSO and ISO 31000 risk management frameworks. While both frameworks aim to establish effective risk management, they differ in their focus and complexity. ISO 31000 is a simpler standard with a broader audience in mind, emphasising the integration of risk management into decision-making for strategic planning. COSO, on the other hand, is more detailed and aimed at accounting and auditing professionals. It focuses on Enterprise Risk Management (ERM) and aligning risk tolerance with overall strategy. Ultimately, the best choice depends on the needs of the agricultural producers. If they prioritise ease of implementation, ISO 31000 may be a good fit. But if they need in-depth guidance on risk tolerance and strategy development, COSO may be more beneficial. They might even consider combining elements from both frameworks for a more comprehensive approach. The key is to continually evaluate and adjust the chosen system to best meet their farm's objectives.

With regard to the level of the role of governments in terms of strategies, instruments and tools to promote agricultural and rural development, the World Bank (2005) recommends a three-pronged approach for governments to determine their role in ARM. First, they should consider the potential economic benefits of ARM instruments, the specific risks faced by their farmers, and the challenges of implementing instruments such as insurance. Second, governments typically balance four factors when designing ARM policies: fiscal constraints, economic growth objectives, the promotion of market-based risk transfer mechanisms, and the achievement of social objectives such as rural poverty reduction. In short, there is no one--size-fits-all approach, an effective ARM policy takes into account both economic and social objectives.

Traditionally, European ARM has focused on yield variability through production insurance and technological innovation, neglecting price stabilisation tools (Schaffnit-Chatterjee, 2010). The EU Common Agricultural Policy (CAP) offers options such as Income Stabilisation Tools (IST) through Mutual Funds (MFs) to compensate for income losses (Rippo & Cerroni, 2022). MFs are different from insurance; they allow farmers to save collectively against potential losses due to specific events (Rippo & Cerroni, 2022). While some see investment funds as a complementary risk management tool (Janowicz-Lomott & Łyskawa, 2014), the effectiveness of ISTs compared to direct payments or crop diversification is debated (El Benni et al., 2016; Castañeda-Vera & Garrido, 2017). The new CAP 2023-2027 emphasises sustainability and allows more flexibility for member states to design ARM programmes according to their specific needs. However, challenges remain, such as limited participation in MFs due to complex guidelines (García-Machado et al., 2017; Cordier & Santeramo, 2020).

2.3. Risk Assessment and Bibliometric Analysis on ARMT

Consistent with OECD (2009a), a holistic assessment of agricultural risk management tools (ARMT) considers all available instruments, both on and off the farm, and identifies the role of government policies. Various studies have explored how to assess farm resilience (Meuwissen et al., 2019; Slijper et al., 2020), but all emphasise the importance of a system-level approach that considers the ability of farms to adapt to different challenges over time. Research methods include surveys, interviews and stakeholder workshops to capture both quantitative data and the experiences of those involved in the farming system (Meuwissen et al., 2019; Spiegel et al., 2020; Grzelczak et al., 2023).

Over the last few years, many bibliometric analyses have been carried out focusing on different subject areas of the agricultural sector. Others have done so indirectly, such as Meteorology and Atmospheric Sciences, Geoscience, Engineering, Environmental Sciences, Public, Environmental & Occupational Health, etc.

Agricultural research covers a wide range of issues beyond crop production. While Aleixandre-Benavent et al. (2017), Durán Sánchez et al. (2017) and De Natale et al. (2023) examine different aspects of climate change impacts on agriculture (wine tourism, drought and heat indices), Liu et al. (2023) look at non-point source pollution from non-irrigated farms. Magesa et al. (2023) focus on how smallholder farmers are adapting to these very issues. Even specific risks to livestock farmers, such as infectious diseases and farmer mortality, have been examined by Huirne et al. (2000). Takeuchi et al. (2014) further emphasise the need for ongoing research by reviewing the risk assessment and management of emerging technologies, such as nanomaterials in agriculture (FAO & Weltgesundheitsorganisation, 2013). This all highlights the importance of comprehensive research to ensure the sustainability of agriculture in the face of multiple challenges.

Focusing further on the topic, it has been found that very few recent papers research the issue. For example, Duong et al. (2019), in their interesting analysis of 197 studies show that weather, climate change and biosecurity threats are top concerns, while technology is perceived as less risky. Farmers often use diversification and pest prevention strategies to manage these risks. However, limited access to information and credit, especially in developing countries, can hinder effective risk management. Čop & Njavro (2022) add a behavioural economics perspective to this research. In their review of 20 studies, they highlight the use of discrete choice experiments to understand farmers' decision-making in risk management. They point out that current research focuses primarily on on-farm strategies and small-scale risk transfer, often neglecting broader economic factors and larger-scale solutions. In conclusion, both studies emphasise the need for a comprehensive understanding of farmers' risk perceptions and the importance of developing accessible risk management strategies.

3. RESEARCH DESIGN AND METHOD

3.1. Dataset

The first step is to construct a representative dataset of the documents on risk management tools in the agriculture sector. To construct this dataset, in order to find the most relevant studies for the research, they were compiled from the Web of Science Core Collection (WoSCC) and Scopus databases. These two databases are the main global sources of bibliographic references and citations of periodicals, and they could be accessed through the University Library of the University of Huelva (Spain), thanks to licences managed by the Spanish Foundation for Science and Technology (FECYT). The period corresponding to the dataset comprises 10 years, from 2014 to 2023. This period is representative of the latest developments in this subject. During this time, the field was in a period of significant growth and is now more interdisciplinary. To collect the research documents and create the research dataset, the aforementioned databases were used, which are explained in Table 1 and Figure 1. Figure 2 shows the evolution of the number of research articles collected in both databases.

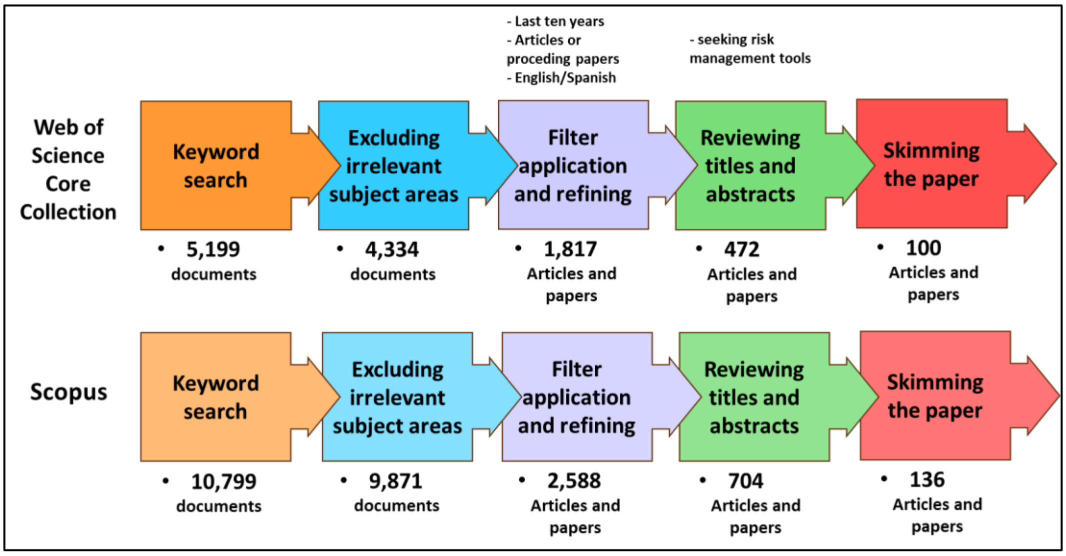
Table 4. Data collection and results detailed conditions

Descriptions	Conditions/results	
Search target DB	**Web of Science Core Collection**	**Scopus**
Search expression	'risk management' AND 'Agricultur*' AND 'tool* OR method* OR techni*'	'risk management' AND 'Agricultur*' AND 'tool* OR method* OR techni*'
Search field	Topic, Title, Keywords, and Abstract	Topic, Title, Keywords, and Abstract
First search results	5,199	10,799
Document types (only research articles and papers)	472	704
Search period (last ten years)	2014 – 2023 (August)	2014 – 2023 (August)
Last search date	30/08/2023	31/08/2023
Refined search results	100	136

Source: Web of Science, Scopus, and own research.

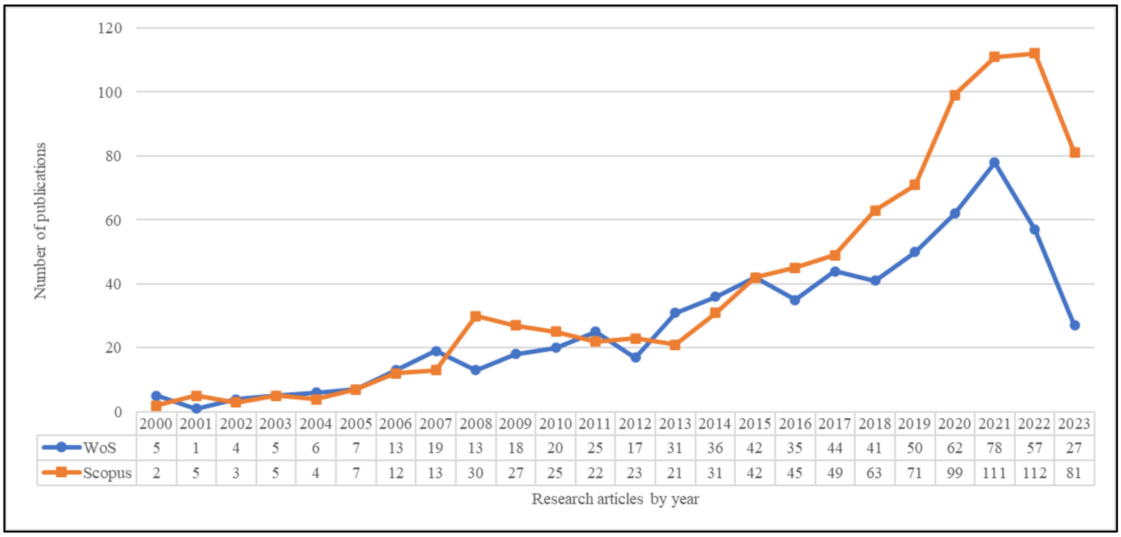
The final result was 100 articles in 74 journals, written by 320 authors for WoSCC and 136 articles, 90 journals and 435 authors for Scopus.

Figure 1. Screening and refinement process for data collection



Source: Web of Science, Scopus, and own research.

Figure 2. Evolution of the numbers of articles collected from WoSCC and Scopus databases



Source: Web of Science, Scopus, and own research.

3.2. Research methodology

A Systematic Literature Review (SLR) and a bibliometric mapping approach were used in order to analyse the dataset and identify the latest topics, countries, journals and authors in agricultural risk management tools, and to visualise their interrelations. The SLR has been developed from an international perspective including all the countries (Pati & Lorusso, 2018; Sauer & Seuring, 2023).

Bibliometrics, the study of the quantitative analysis of publications, uses a technique called bibliometric mapping to create visual representations of links between specific elements, named 'unit of interest'. These elements, such as documents, authors, or keywords, may be linked by citations, shared authorship, or simply by terms appearing together in titles, abstracts, and keywords. In our research, we focus on how key terms in Agricultural Risk Management Tools (ARMT) co-occur within articles, and use this information to create a 'term map' that shows connections between these terms. Similar maps are often referred to as co-word maps in the academic literature (Heersmink et al., 2011).

VOSviewer, a free computer program (https://www.vosviewer.com/), was used to construct and analyse the bibliometric maps. This technique offers advantages over traditional methods (Van Eck et al., 2010a) and excels at presenting large and complex maps in a user-friendly manner. Available to the entire bibliometric research community, VOSviewer allows the construction of various maps based on co-citation or co-occurrence data, including author networks, journal clusters and keyword relationships. The built-in viewer allows detailed exploration of these maps, with customisable display options that highlight different aspects depending on the size and complexity of the map (particularly useful for maps with more than 100 elements). For the underlying mapping technique itself, we refer to Van Eck and Waltman (2007a; 2007b), Van Eck et al. (2010a; 2010b) and Waltman et al. (2010).

VOSviewer (Van Eck et al., 2010b) was used to identify frequently occurring terms (occurring at least 4 times) in the titles, keywords and abstracts of highly cited articles. The co-occurrence of these terms within the same article became the measure of their relatedness. This information was then fed into the VOSviewer software to create a two-dimensional term map. Terms are positioned based on their frequency of co-occurrence, with shorter distances indicating stronger relationships. Colours assigned to each term visually represent clusters, where terms of the same colour tend to co-occur more frequently and have a closer relationship. This clustering helps to identify thematic groupings within the broader field. The resulting map offers two main visualisations: network and density. In the network view, terms are sized and labelled according to their importance, with lines connecting terms based on their co-occurrence strength. This approach allows researchers to explore the relationships between key terms within the selected dataset (Van Eck & Waltman, 2023).

4. RESULTS

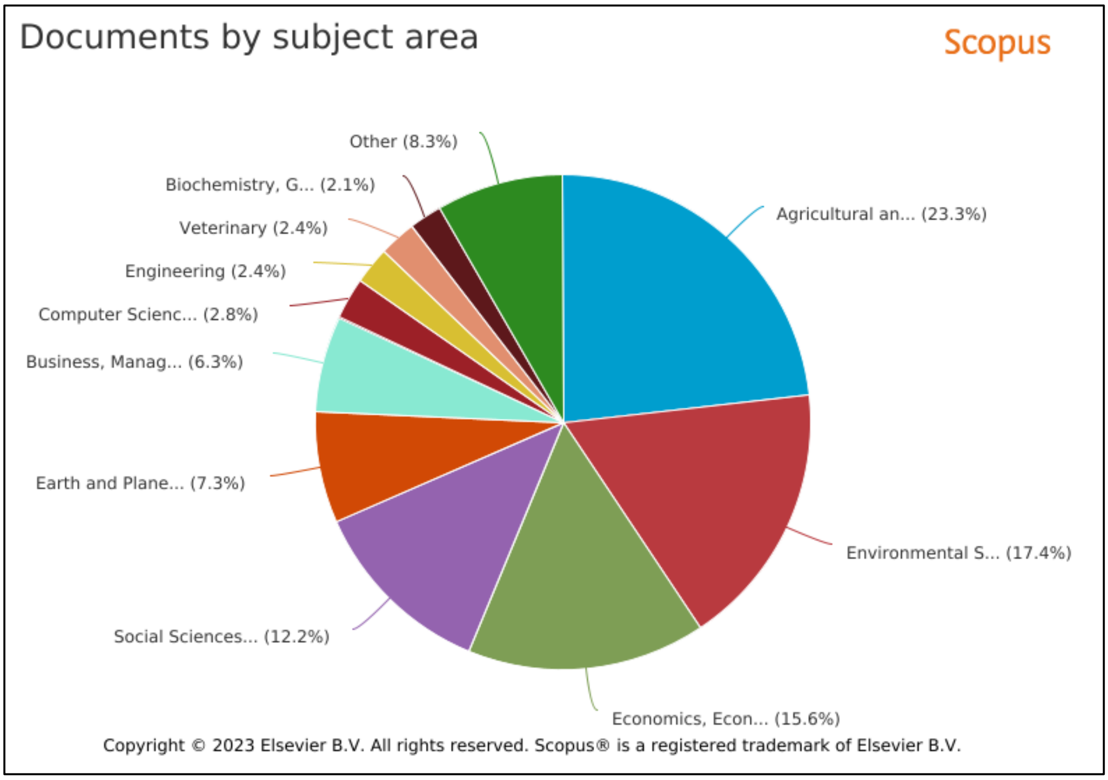
4.1. Analyses by categories and countries

The following figures show the main documents by categories/subjects and countries/regions collected in both WoSCC and Scopus databases. As it can be seen, the top papers in WoSCC belong to the category 'Agricultural Economics Policy' with 18, followed by 'Environmental Sciences' with 17 and 'Economics' and 'Meteorology Atmospheric Sciences' both with 15. In Scopus, the ranking is different but very similar and follows the same pattern.

Figure 3. WoSCC documents by categories/subjects

Source: Web of Science.

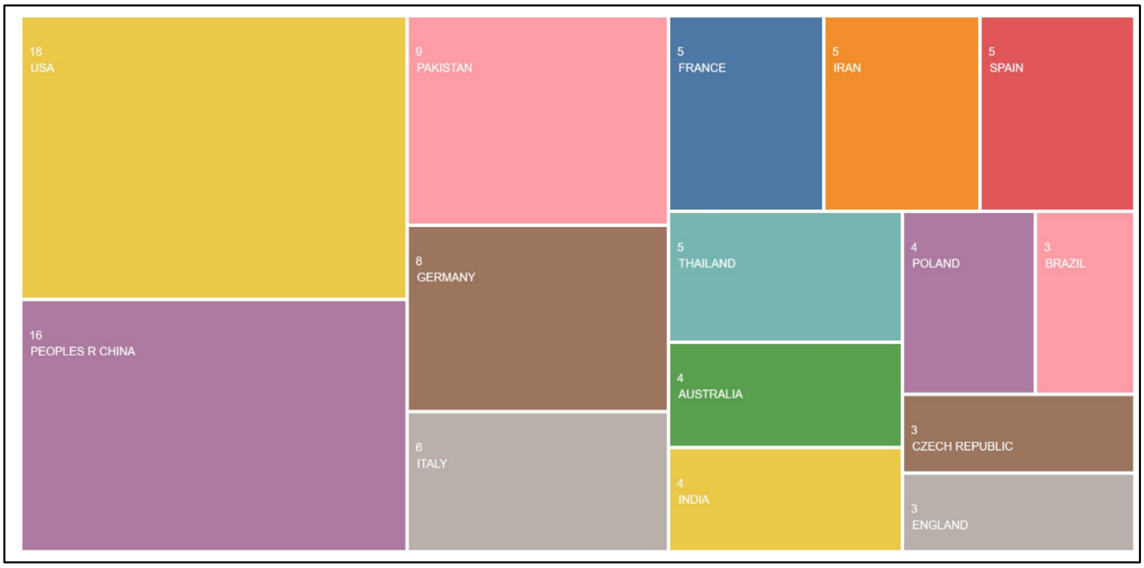
Figure 4. Scopus documents by categories/subjects



Source: Scopus.

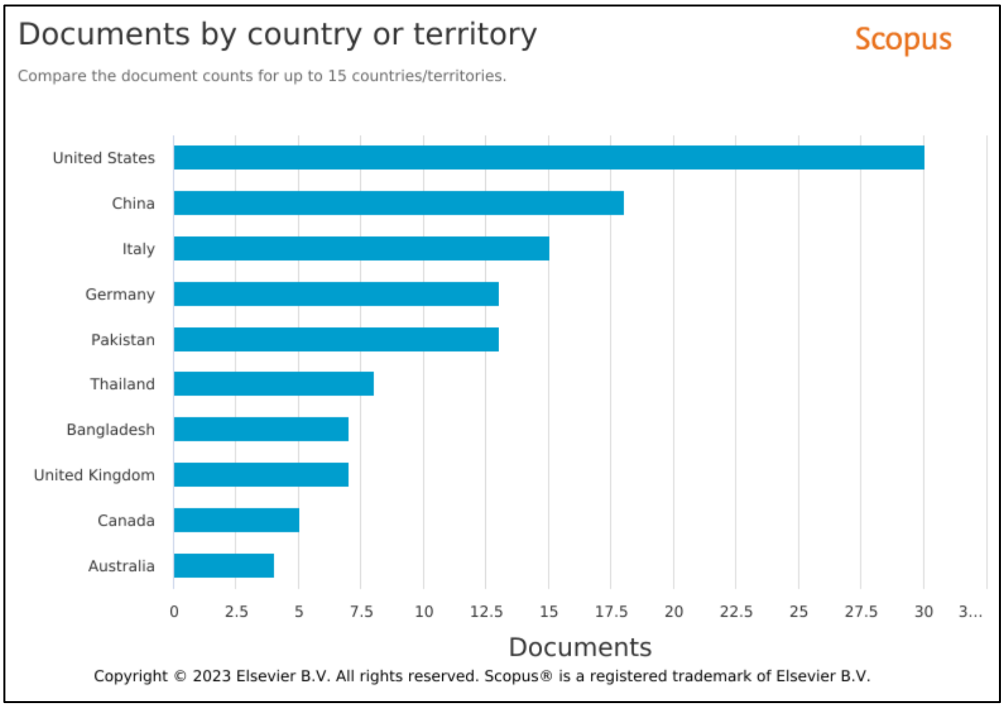
By country, the top five are also the same, and although Italy, Germany and Pakistan change their order, the United States and China are the leaders in publications in this field.

Figure 5. WoSCC documents by main countries/regions



Source: Web of Science.

Figure 6. Scopus documents by main countries/regions



Source: Scopus.

4.2. Most productive and leading journals

Tables 5 and 6 show the Top-10 highly productive and prominent journals in ARMT collected from WoSCC and Scopus.

Table 5. Top-10 highly productive journals collected from WoSCC

Rank	Source title	Record Count	% of 100
1	Agriculture	4	4.00%
2	Climate Change	4	4.00%
3	Natural Hazards	4	4.00%
4	Agricultural Finance Review	3	3.00%
5	Computers and Electronics in Agriculture	3	3.00%
6	International Journal of Disaster Risk Reduction	3	3.00%
7	Journal of Risk and Financial Management	3	3.00%
8	Land Use Policy	3	3.00%
9	Risk in the Food Economy Theory and Practice	3	3.00%
10	Agricultural Systems	2	2.00%

Source: Web of Science.

Table 6. Top-10 highly productive journals collected from Scopus

Rank	Source title	Record Count	% of 136
1	Agricultural Finance Review	6	4.41%
2	Natural Hazards	5	3.68%
3	International Journal of Disaster Risk Reduction	4	2.94%
4	Agriculture	4	2.94%
5	Sustainability	3	3.03%
6	Land Use Policy	3	2.21%
7	Journal of Agriculture and Food Research	3	2.21%
8	International Food and Agribusiness Management Review	3	2.21%
9	Eurochoices	3	2.21%
10	Environmental Science and Pollution Research	3	2.21%

Source: Scopus.

4.3. Most cited articles

Tables 7 and 8 show the Top-10 most cited articles list collected from WoS and Scopus, and as it can be seen three of them are in the top ten of the most cited articles in both of these lists.

Table 7. Top-10 of the most cited articles in WoSCC

Rank	Article title (Journal)	Author/s (Year)	Times Cited
1	*2*	*3*	*4*
1	How well do meteorological indicators represent agricultural and forest drought across Europe? (*Environmental Research Letters*)	S. Bachmair, M. Tanguy, J. Hannaford & K. Stahl (2018)	87
2	Managing catastrophic risks in agriculture: Simultaneous adoption of diversification and precautionary savings (*International Journal of Disaster Risk Reduction*)	R. Ullah, D. Jourdain, G. P. Shivakoti & S. Dhakal (2015)	80
3	Bank erosion in agricultural drainage networks: New challenges from structure-from-motion photogrammetry for post-event analysis: sfm for Post-Event Analysis (*Earth Surface Processes and Landforms*)	M. Prosdocimi, S. Calligaro, G. Sofia, G. Dalla Fontana & P. Tarolli (2015)	70
4	Vulnerability of Southern Plains agriculture to climate change (*Climatic Change*)	J. L. Steiner, D. D. Briske, D. P. Brown & C. M. Rottler (2018)	66

Table 7 cont.

1	2	3	4
5	Risk identification of agricultural drought for sustainable Agroecosystems (*Natural Hazards and Earth System Sciences*)	N. R. Dalezios, A. Blanta, N. V. Spyropoulos & A. M. Tarquis (2014)	47
6	Crop insurance and pesticide use in European agriculture (*Agricultural Systems*)	N. Möhring, T. Dalhaus, G. Enjolras & R. Finger (2020)	42
7	Maize production under risk: The simultaneous adoption of off-farm income diversification and agricultural credit to manage risk (*Journal of Integrative Agriculture*)	S. Akhtar, G. Li, A. Nazir, A. Razzaq, R. Ullah, M. Faisal, M. A. U. R. Naseer & M. H. Raza (2019)	41
8	Adoption of On-Farm and Off-Farm Diversification to Manage Agricultural Risks: Are These Decisions Correlated? (*Outlook on Agriculture*)	R. Ullah & G. P. Shivakoti (2014)	39
9	Developing an integrated risk management framework for agricultural water conveyance and distribution systems within fuzzy decision-making approaches (*Science of The Total Environment*)	M. Orojloo, S. M. Hashemy Shahdany & A. Roozbahani (2018)	38
10	Agricultural Risk Management Using Fuzzy TOPSIS Analytical Hierarchy Process (AHP) and Failure Mode and Effects Analysis (FMEA) (*Agriculture*)	P. Zandi, M. Rahmani, M. Khanian & A. Mosavi (2020)	35

Source: Web of Science.

Table 8. Top-10 of the most cited articles in Scopus

Rank	Article title (*Journal*)	Author/s (Year)	Times Cited
1	2	3	4
1	Keystone microbial taxa regulate the invasion of a fungal pathogen in agro-ecosystems (*Soil Biology and Biochemistry*)	P. Trivedi, M. Delgado-Baquerizo, C. Trivedi, K. Hamonts, I. C. Anderson & B. K. Singh (2017)	126
2	Factors affecting farmers' risk attitude and risk perceptions: The case of Khyber Pakhtunkhwa, Pakistan (*International Journal of Disaster Risk Reduction*)	R. Ullah, G. P. Shivakoti & G. Ali (2015)	115
3	Managing catastrophic risks in agriculture: Simultaneous adoption of diversification and precautionary savings (*International Journal of Disaster Risk Reduction*)	R. Ullah, D. Jourdain, G. P. Shivakoti & S. Dhakal (2015)	90
4	Precipitation effects on microbial pollution in a river: Lag structures and seasonal effect modification (*PLoS ONE*)	A. Tornevi, O. Bergstedt & B. Forsberg (2014)	74
5	Farm risks and uncertainties: Sources, impacts and management (*Outlook on Agriculture*)	R. Ullah, G. P. Shivakoti, F. Zulfiqar M.A. & Kamran (2016)	49

Table 8 cont.

1	*2*	*3*	*4*
6	Crop insurance and pesticide use in European agriculture (*Agricultural Systems*)	N. Möhring, T. Dalhaus, G. Enjolras & R. Finger (2020)	45
7	Maize production under risk: The simultaneous adoption of off-farm income diversification and agricultural credit to manage risk (*Journal of Integrative Agriculture*)	S. Akhtar, G. Li, A. Nazir, A. Razzaq, R. Ullah, M. Faisal, M. A. U. R. Naseer & M. H. Raza (2019)	45
8	Analysis of wheat farmers' risk perceptions and attitudes: evidence from Punjab, Pakistan (*Natural Hazards*)	D. Ahmad, M. Afzal & A. Rauf (2019)	44
9	Vulnerability of specialty crops to short-term climatic variability and adaptation strategies in the Midwestern USA (*Climatic Change*)	E. Kistner, O. Kellner, J. Andresen, D. Todey & L. W. Morton (2018)	41
10	Managing weather and climate risks to agriculture in North America, Central America and the Caribbean (*Weather and Climate Extremes*)	H. D. Shannon & R. P. Moth, (2015)	38

Source: Scopus.

4.4. Most productive authors

Tables 9 and 10 display the Top-10 of most productive authors publishing on agricultural risk management tools in WoS and Scopus. In this section, authors' contributions are analysed using the VOSviewer's standard attribute of the total link strength (Van Eck & Waltman, 2023) and the combined method of the average of the number of citations received divided by the number of papers published (Merigó & Yang, 2017).

Table 9. Top-10 of the most productive authors in WoSCC

No.	Author	Documents	Citations	Total link strength	Average
1	Raza Ullah	6	216	139	36
2	Ganesh P. Shivakoti	4	152	103	38
3	Robert Finger	2	59	2	29.5
4	Shoaib Akhtar	2	45	22	22.5
5	Muhammad Faisal	2	45	22	22.5
6	Giuliano Di Tommaso	2	38	0	19
7	K. M. Mehedi Adnan	2	17	49	8.5
8	Manuela Ender	2	11	2	5.5
9	Pratap S. Birthal	2	6	0	3
10	Andrea Bohacikova	2	4	0	2

Source: Web of Science and own research.

Table 10. Top-10 of the most productive authors in Scopus

No.	Author	Documents	Citations	Total link strength	Average
1	Raza Ullah	8	417	334	52.13
2	Ganesh P. Shivakoti	5	315	205	63
3	K. M. Mehedi Adnan	5	62	187	12.4
4	S. A. Sarker,	5	62	187	12.4
5	S. Trestini	4	56	36	14
6	Robert Finger	3	60	8	20
7	E. Giampietri	3	54	36	18
8	F. Capitanio	3	17	11	5.67
9	H. Bulut	3	15	1	5
10	J. K. M. Kuwornu	3	13	35	4.33

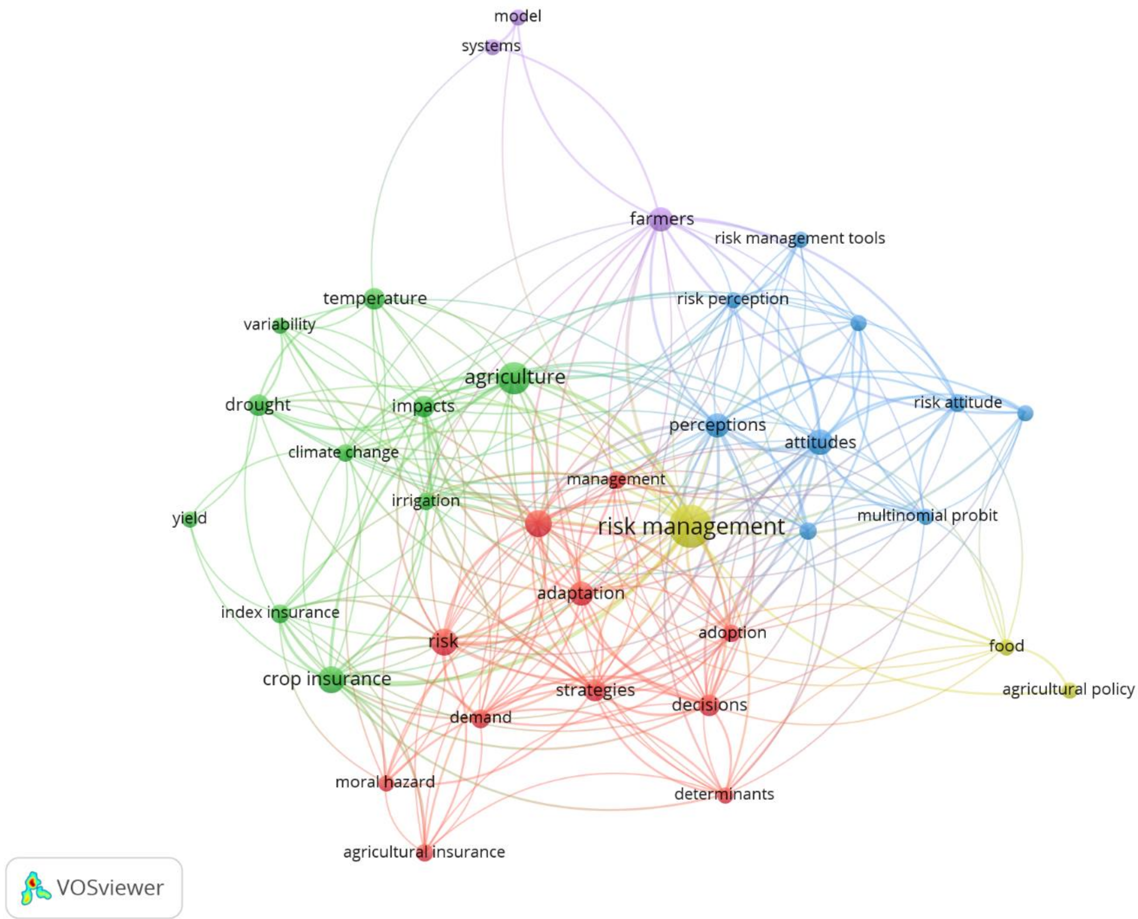
Source: Scopus and own research.

4.5. Word co-occurrence maps

To construct the map, the VOSviewer software, which employs the VOS mapping technique (Van Eck & Waltman, 2007; Van Eck et al., 2010b), was used. Using a computer algorithm (Van Eck et al., 2010b), made it possible to identify key terms in all fields of the articles included in our document collection (titles, abstracts, keywords, etc.).

From the 1,626 words or phrases, only terms that co-occurred at least 4 times in the WoSCC and Scopus databases, in titles, abstracts and keywords, were taken into account. After filtering out generic terms like 'Article', 'Review' or 'Literature', 36 and 50 relevant terms in WoSCC and Scopus respectively, that meet the threshold, were identified. The co-occurrence frequency, which reflects how often terms appear together in documents, was then calculated for each term pair. This data was fed into VOSviewer software to generate a term map. Here, terms with higher co-occurrence are grouped and assigned colours, allowing for visual identification of thematic clusters within the data. This clustering process helps understand the relationships and emerging themes within the field. VOSviewer provides three types of visualisations: network, overlay and density visualisation. The network visualisation shows the map's details, while the density visualisation reflects the evolution of the terms, from the oldest (from dark purple-blue) to the most recent (to light green-yellow). The density visualisation provides an overview indicating the relative importance of the different areas of the map according to clusters. In order not to repeat all the visualisations generated with the VOSviewer software from the key co-occurrence terms in WoSCC and Scopus, only those from WoSCC from will be shown. Figures 7, 8 and 9 show the different types of map visualisations of 36 co-occurring key terms on risk management tools in the agricultural sector.

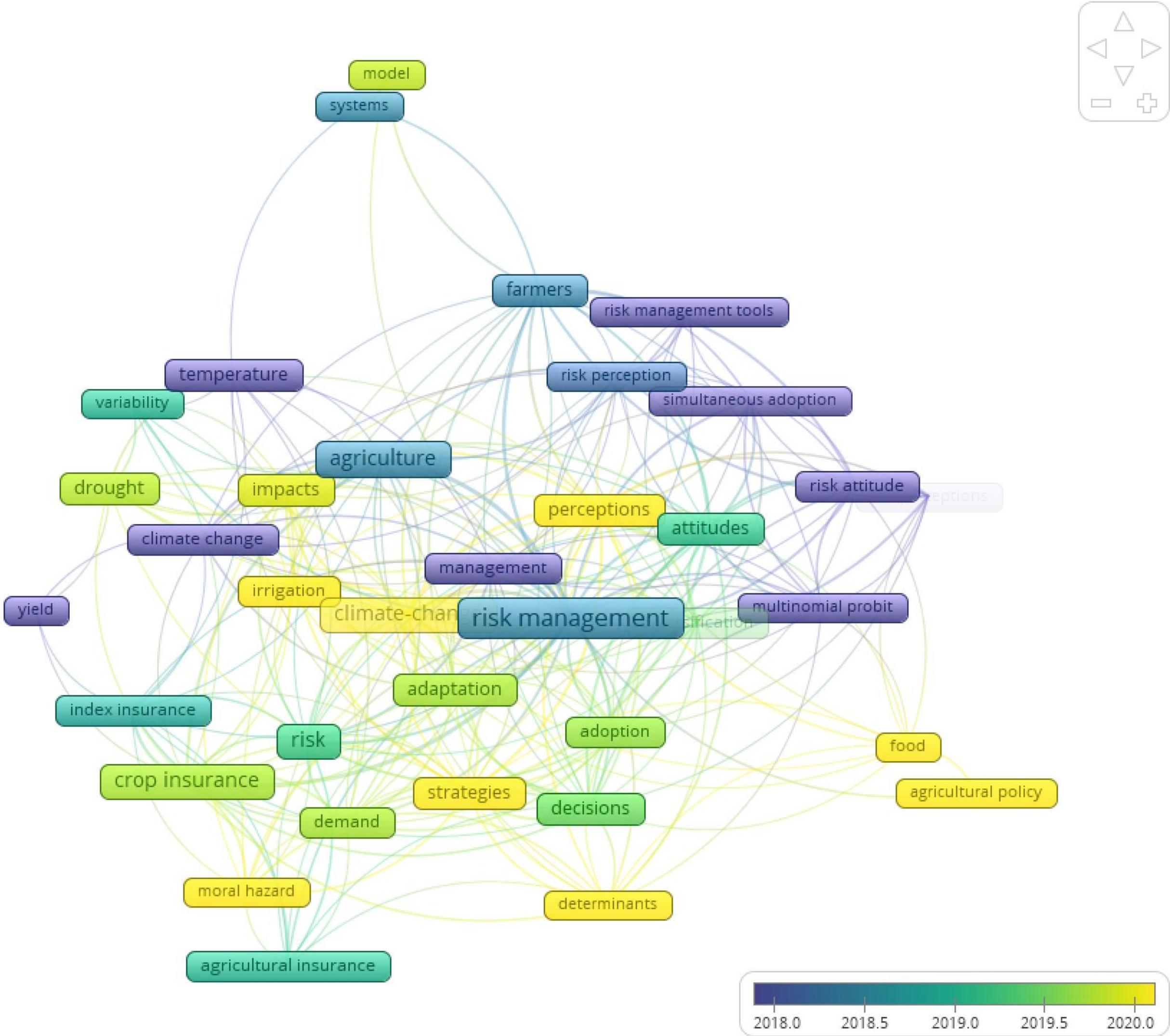
Figure 7. Map of 36 key terms on ARMT in WoSCC (Network visualization labels in circles)



Source: Own research.

As it can be seen in Figure 8, the most recent key terms in the latest scientific articles are related to new issues such as irrigation (also called watering), perceptions, moral hazard (lack of incentive to avoid risk when protected from its consequences, e.g. by insurance), strategies, determinants, food and agricultural policy, while the older ones are more related to management, temperature, yield, simultaneous adoption or risk management tools. It is worth noting that the term climate change appears in both colours (as new and as old), because it was previously used as two separate words and now appears as only one word separated by a hyphen, but it is still one of the focus of attention of the risks perceived by farmers.

Figure 8. Map of 36 key terms on ARMT in WoSCC (Overlay visualisation with labels in frames)

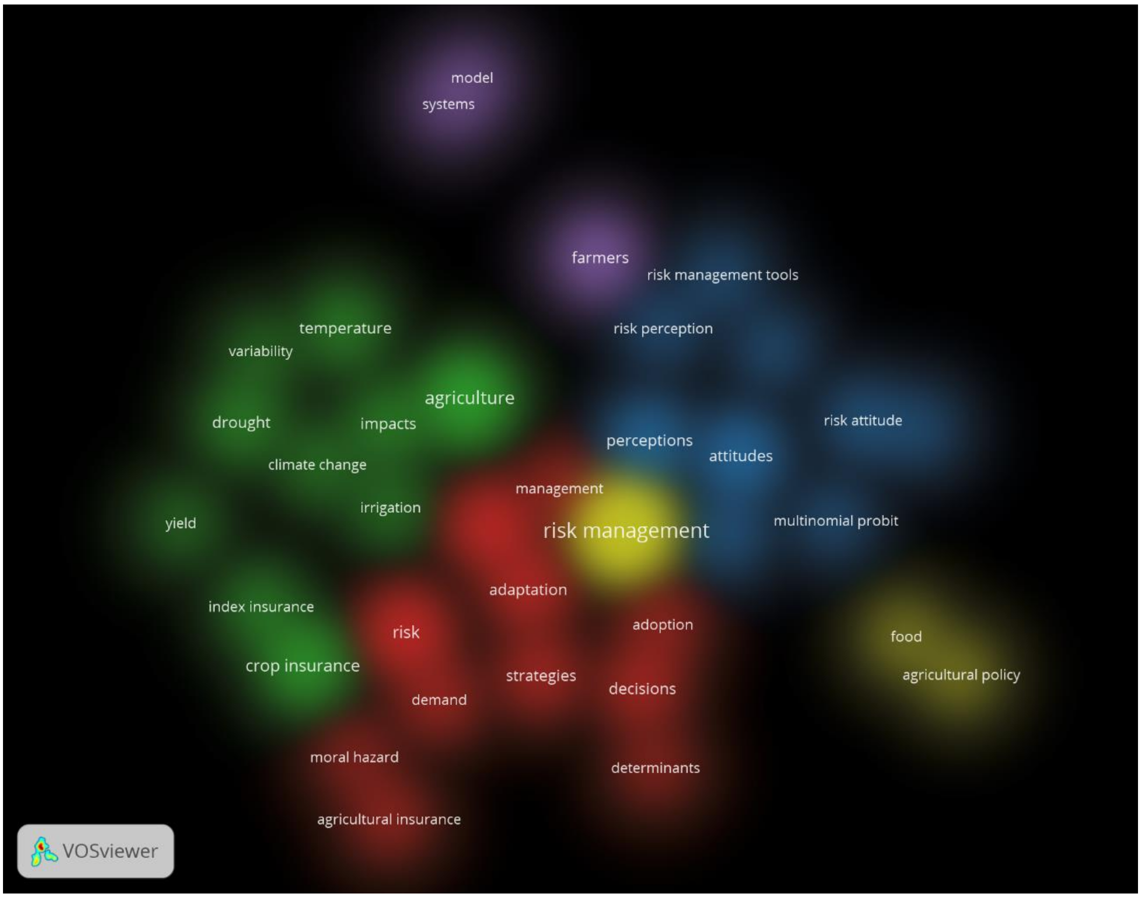


Source: Own research.

Figure 9 uses cluster density visualisation, a technique only applicable to data with assigned clusters. Here, the colour displayed at each point on the map is a mixture of the colours assigned to its surrounding clusters. The specific weight given to each cluster's colour is determined by the number of terms from that cluster present in the vicinity of that point. This approach helps to visualise thematic density within the map, highlighting areas with a concentration of terms from particular clusters.

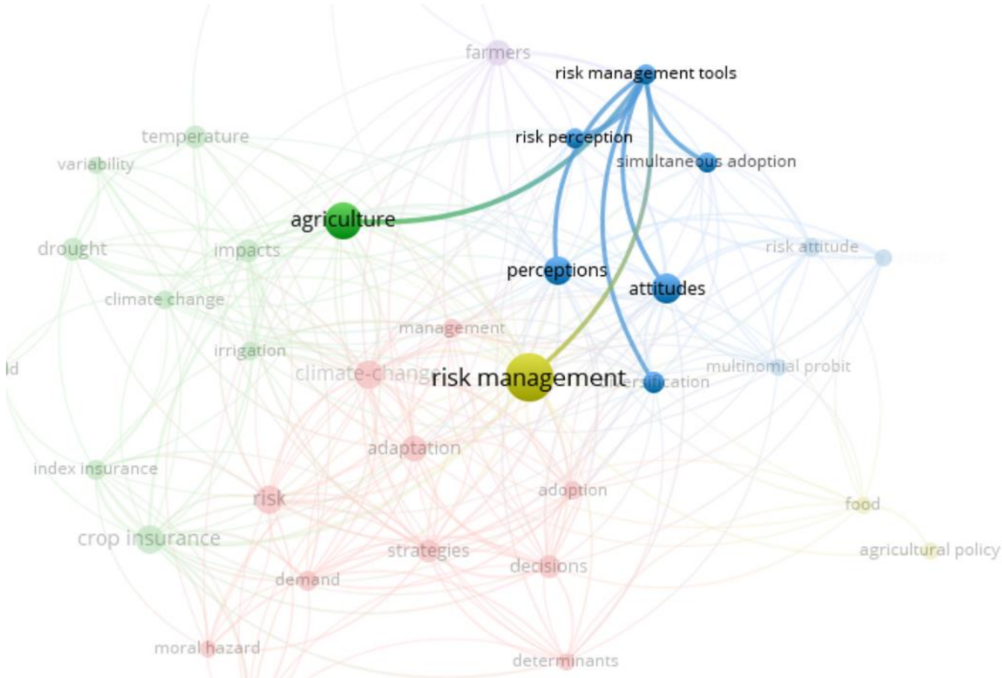
Figures 10, 11, and 12 show in detail the relationships of risk management tools, risk management and strategies with those more co-occurring key terms.

Figure 9. Map of 36 key terms on ARMT in WoSCC (Cluster density visualisation)



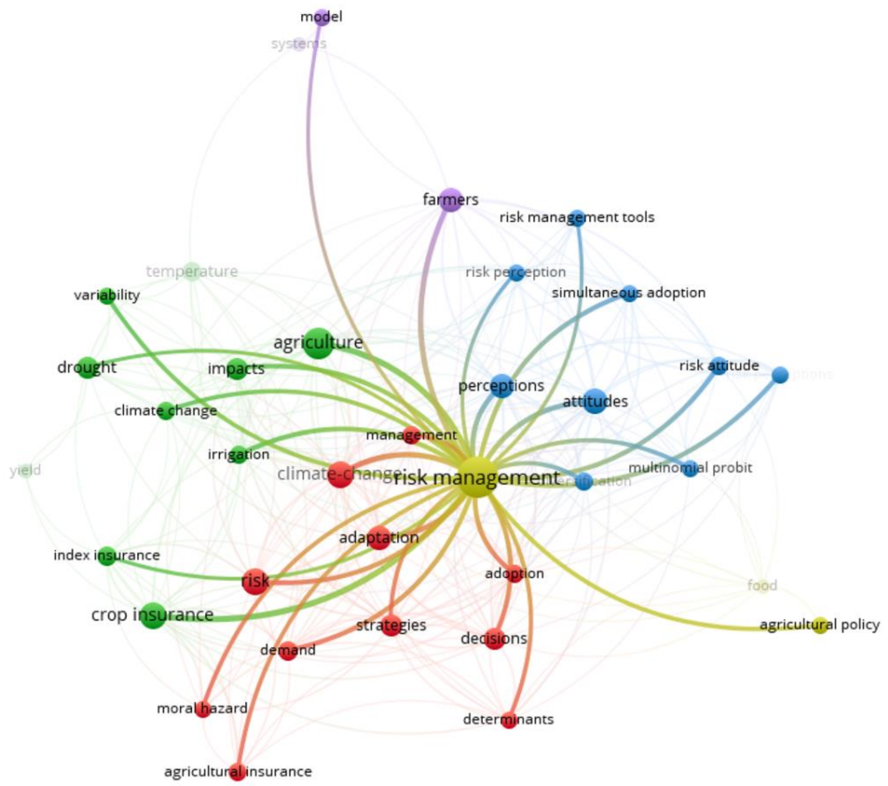
Source: Own research.

Figure 10. Map of 36 key terms on ARMT in WoSCC (focused on the 'risk management tools' term)



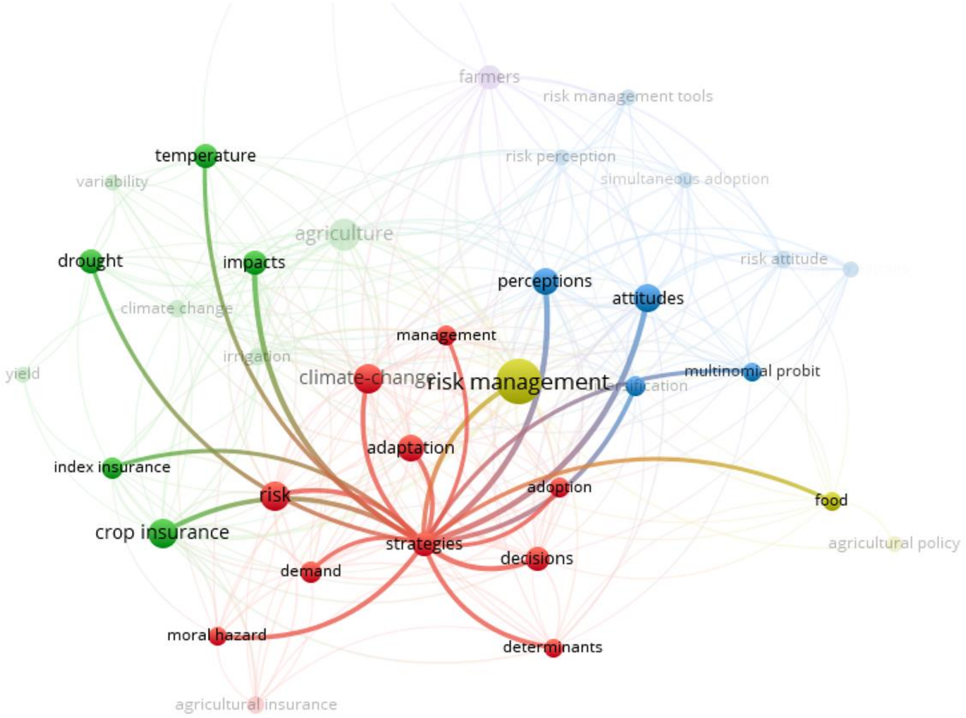
Source: Own research.

Figure 11. Map of 36 key terms on ARMT in WoSCC (focused on the 'risk management' term)



Source: Own research.

Figure 12. Map of 36 key terms on ARMT in WoSCC (focused on the 'Strategies' term)



Source: Own research.

4.6. Linking clusters to risk management tools

Table 11 shows the 36 most frequently co-occurring terms at least 4 times in the WoSCC dataset that comprise each cluster in the most recent period of the last ten years. The results of the algorithm, after running the VOSviewer program, give rise to 5 clusters. Each cluster has been labelled according to the highest number of co-occurrences and the total linking strength of its main top terms. The key terms corresponding to agricultural risk management (ARM) are also identified in bold. Lastly, each cluster is related to the general and/or specific risk management tool.

Table 11. The most frequent co-occurrence of terms in every cluster in the latest time period

Number of terms	Clusters	Number of occurrences	Total link strength	Tools (examples)
1	*2*	*3*	*4*	*5*
	Cluster 1: 'Strategy decisions on adaptation to climate change'			
1	**Adaptation**	**9**	**41**	Multiple-peril insurance Whole-farm yield insurance Index insurance contracts Weather-index-based insurance Climate Smart Agriculture (CSA) Cooperation with other farmers
2	Adoption	5	25	
3	Agricultural insurance	5	14	
4	**Climate-change**	**11**	**55**	
5	**Decisions**	**7**	**38**	
6	Demand	6	29	
7	Determinants	4	22	
8	Management	5	20	
9	Moral hazard	4	16	
10	Risk	12	32	
11	**Strategies**	**7**	**38**	
	Cluster 2: 'Risk impacts on agricultural production'			
12	**Agriculture**	**17**	**37**	Single-risk insurance Multiple-peril insurance Whole-farm yield Mutual stabilisation funds Crop sharing
13	Climate change	5	18	
14	**Crop insurance**	**12**	**43**	
15	Drought	7	17	
16	**Impacts**	**7**	**35**	
17	Index insurance	6	18	
18	Irrigation	5	21	
19	Temperature	7	12	
20	Variability	4	11	
21	Yield	4	4	
	Cluster 3: 'Attitudes towards risk management tools'			
22	**Attitudes**	**11**	**54**	Risk assessment models Crop and enterprise diversification Commodity Exchanges and Futures Markets
23	**Diversification**	**5**	**23**	
24	Multinomial probit	4	22	
25	**Perceptions**	**9**	**55**	
26	**Risk attitude**	**5**	**24**	
27	Risk management tools	4	9	
28	Risk perception	4	18	
29	Risk perceptions	4	19	
30	Simultaneous adoption	4	22	

Table 11 cont.

1	*2*	*3*	*4*	*5*
	Cluster 4: 'Agricultural policy and risk management'			
31	Agricultural policy	4	4	Asset and Income
32	Food	4	14	Based Strategies
33	**Risk management**	**29**	**88**	Public risk management tools
	Cluster 5: 'Farms management systems and models'			
34	**Farmers**	**9**	**36**	Contract Farming
35	Model	4	6	Vertical integration
36	Systems	4	6	Agricultural Finance

Source: Own research.

5. CONCLUSIONS, IMPLICATIONS AND FUTURE RESEARCH

The study provides a thorough and unbiased analysis of current agricultural risk management tool research. 100 articles from 74 journals and 320 authors in the WoSCC database were examined, alongside 136 articles from 90 journals and 435 authors in Scopus. This comprehensive dataset provides a solid foundation for understanding the current state of research in this field. This representative dataset of articles published in leading journals has been analysed using VOSviewer software. Based on the frequency of co-occurrence of key terms, several term maps provide visual representations of the latest research in the Agricultural Risk Management Tools (ARMT) and, more specifically, of the grouping around five main clusters, namely Strategy Decisions on Adaptation to Climate Change, Risk Impacts on Agricultural Production, Attitudes towards Risk Management Tools, Agricultural Policy and Risk Management, and Farms Management Systems and Models.

In agreement with Ullah et al. (2016), in the literature review few bibliometric analyses studies of published scientific articles on Agricultural Risk Management Tools (ARMT) in the WoSCC and Scopus databases were found. Most of the publications found are from organisations such as the FAO, the World Bank, or financial institutions such as Deutsche Bank.

Innovations in agricultural risk management instruments by the EU in the former CAP, such as the risk management strategy based on Income Stabilisation Tools (ISTs) through the creation of agricultural Mutual Funds (MFs), have not been as well received by farmers, Member States, and autonomous governments as expected, and their implementation has been rather scarce.

The impact in the past on the EU budget concerning the high costs of storing agricultural surpluses in fats and other agricultural-derived products to avoid falling market prices (oil, milk, butter, etc.) led to a change in the Common Agricultural Policy with the introduction of new market-based risk management tools. However, it seems that European farmers are not convinced by this new system. This is partly because of their limited experience in using contracts such as agricultural futures and options and their trading on commodity exchanges, and partly because of the well-functioning agricultural insurance systems in the Member States (as the Spanish agricultural insurance system). It is also possible due to the low financial incentives given to the establishment of the IST and mutual funds, which have not persuaded farmers to change their already familiar on-farm risk management system. As Huirne (2000) states, the main risk management strategies for farmers are to produce at the lowest cost and to buy insurance. Another possible reason is the subsidy that farmers receive from government agencies and ministries of agriculture (such as in the case of Spain) to finance the underwriting of agricultural insurance policies. This would explain why attempts to establish derivative futures and options markets for agricultural products in Europe have been unsuccessful.

The study indicates that farmers' risk management requires the acquisition of knowledge of risk management tools, specifically differentiating between on-farm and off-farm instruments, and the training competences necessary for their implementation which are acquired both through their business management and others developed during the work in the crops, farming and agroindustry. According to the interviews with farmers, rather than preferring agricultural insurance to cope with production damage, price insurance or whole farm income insurance would be ideal.

According to Spiegel et al. (2020), Agricultural risk management (ARM) is most effective when it considers the whole farming system and the different actors. It should be a dynamic process that adapts to changing risks (Mitchell & Harris, 2012). Collaboration and coordinated policies are crucial for successful implementation, with incentives tailored to the specific needs of different stakeholders (Finger et al., 2022). Ultimately, effective ARM strengthens rural communities and paves the way for broader economic development (Kalogiannidis et al., 2023). On this basis, it would be a good idea to analyse these aspects in a new study to examine whether they are indeed being applied using both this approach as well as the COSO/ISO framework in the management of agricultural risks.

Future research could also explore the impact of the new CAP 2023-27 policy, which aims to position agriculture and rural areas as central to achieving the goals of the European Green Pact and the UN's 2030 Agenda for Sustainable Development. This policy is intended to be a key instrument for delivering the Farm-to-Fork Strategy's focus on food safety (Takeuchi et al., 2014) and biodiversity, while aligning with broader EU objectives for social, environmental and economic sustainability in agriculture and rural areas.

However, the new CAP is uncertain and the future is faced with shortages of products due to crop variability caused by climate change, political crises (including the ongoing war in Ukraine) and consequently greater volatility and higher prices.

Finally, the findings would benefit scholars in need of information on research on risk management tools in the agricultural sector, and they would also constitute a reference guide for researchers wishing to conduct further studies related to this subject.

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