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Impacts of Cropping Systems on Plant Biodiversity and the Dynamics of Invasive Plants in Irrigated Areas: A Bibliometric Analysis

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ABSTRACT

This bibliometric analysis examines the impacts of cropping systems on plant biodiversity and the dynamics of invasive plants in irrigated areas between 2010 and 2025. Using data from Google Scholar and OpenAlex via Publish or Perish, a PRISMA selection process was conducted, and 407 articles were analysed using R and VOSviewer. This analysis highlights thematic trends and the co-occurrence of keywords. Scientific output is on the rise, peaking at 127 articles in 2024. The study reveals a high degree of interdisciplinarity and two main research areas within the field of agriculture and forestry (ACP): intensive systems as opposed to diversified/agroecological systems (61.44% of the variance) and anthropogenic-agronomic factors (28.72%), notably fertilisation, irrigation, tillage and monoculture. The institutional network is dominated by University Putra Malaysia and Asia, whilst Africa remains under-represented. Irrigated intensification, monoculture, chemical inputs and landscape simplification reduce biodiversity and encourage the spread of invasive species. The study recommends agroecological practices, diversified water and crop management, reduced use of inputs and habitat conservation.

INTRODUCTION

Bibliometrics, defined by Rostaing as a quantitative approach to the analysis of scientific publications, is used to map the themes, key figures, and developments within a research field (Rostaing, 1997). This method offers a way to explore, evaluate, and illustrate trends specific to a field. It thus allows not only for measuring the evolution of research but also for identifying major areas of interest and the research angles prioritized by researchers (Gareh & Oulamine, 2025). This method relies on the use of publication metadata (titles, authors, keywords, etc.) to trace the progression of knowledge and highlight leading disciplines, collaborations, emerging concepts, and potential knowledge gaps. Although relatively recent and underutilized in the past, it has garnered growing interest in recent years (Himrane *et al.*, 2024).

When applied to the Sahelian context, which is marked by pressing challenges related to resource management, climate change, and food security, this approach proves particularly relevant. Research on topics such as the impacts of cropping systems on plant biodiversity and the dynamics of invasive plants in irrigated areas is booming there. However, this scientific output often remains scattered, redundant, or difficult for local decision-makers and researchers to access, which limits its impact. A bibliometric analysis can therefore help organize this knowledge, clarify research dynamics (regional or international), and guide future work. More specifically, for studies on the topic in question, it serves as a valuable tool for understanding the historical evolution and structure of scientific research dedicated to this specific issue.

This bibliometric study was carried out under this framework and had the following objectives:

- Identify the major research trends related to agricultural system influences on plant biodiversity and invasive plant dynamics in irrigated areas. The bibliometric study follows the chronological history of publications, giving a clear and thorough picture of the favoured research themes and areas.

- Analyse the co-occurrence of keywords to determine the main scientific ideas connected with impacts, cropping systems, plant biodiversity, invasive plants, irrigated areas, agricultural resilience, and sustainable practices.

MATERIALS AND METHODS

Data Collection and Bibliometric Analysis

Bibliographic data were collected by querying two databases: Google Scholar (http://scholar.google.com) and OpenAlex (https://openalex.org/works), using the Publish or Perish software (https://harzing.com/resources/publish-or-perish). The search specifically targeted articles on "The impacts of cropping systems on plant biodiversity and the dynamics of invasive plants in irrigated areas."

Bibliometric analysis is an approach for determining the state of the art on a certain issue. This tool was utilised in our research to get a thorough overview of agricultural system impacts, plant biodiversity, and invasive plant dynamics in irrigated areas.

An initial collection of 1,503 general articles on the issue was found for bibliometric analysis using OpenAlex, encompassing the years 2010 to 2025. The metadata from these papers was processed using R software and VOSviewer, allowing us to track trends in keywords, author productivity and citations, journal relevancy, and

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interest in the topic over time. This analysis provides a clearer picture of how the research topic, specifically the effects of cropping techniques on plant biodiversity and the dynamics of invasive plants in irrigated areas, has changed during the articles' collection.

Systematic review of the literature

The literature on the effects of agricultural systems, plant biodiversity, and the dynamics of invasive plants in irrigated areas was thoroughly reviewed. The following terms served as the foundation for the primary keywords utilised to obtain articles: To be as thorough as possible, include impacts, cropping systems, plant biodiversity, invasive plants, irrigated areas, and their synonyms. The OpenAlex database was used to search for publications based on abstracts and titles (August 28, 2025). 1,303 items that could be pertinent to our enquiry were found in this collection. The criteria listed below (Figure 1) in the flow diagram (PRISMA diagram) were used to choose which articles would be kept and examined. First, duplicate articles, articles with no specific connection to the study's subject, articles that do not address the relevant topic, and articles based solely on the information contained in the title and abstract were removed from the list. Next, articles that did not fall within the 2010-2025 timeframe and articles published in languages other than French and English were also excluded. Finally, applying these selection criteria reduced the number of potentially relevant articles from 1,303 to 407 articles relevant to our study.

The initial screening criteria were applied in a different order (impacts, cropping systems, plant biodiversity, invasive plants, and irrigated areas) instead of the original order (plant biodiversity, invasive plants, impacts, cropping systems, and irrigated areas) to verify the robustness of the selection process. This method produced the same number of articles, demonstrating that the keyword order had no bearing on the selection process and that no pertinent studies were unintentionally left out.

In compliance with the systematic literature review approach, a structured set of procedures was created after the final selection to direct data extraction from the

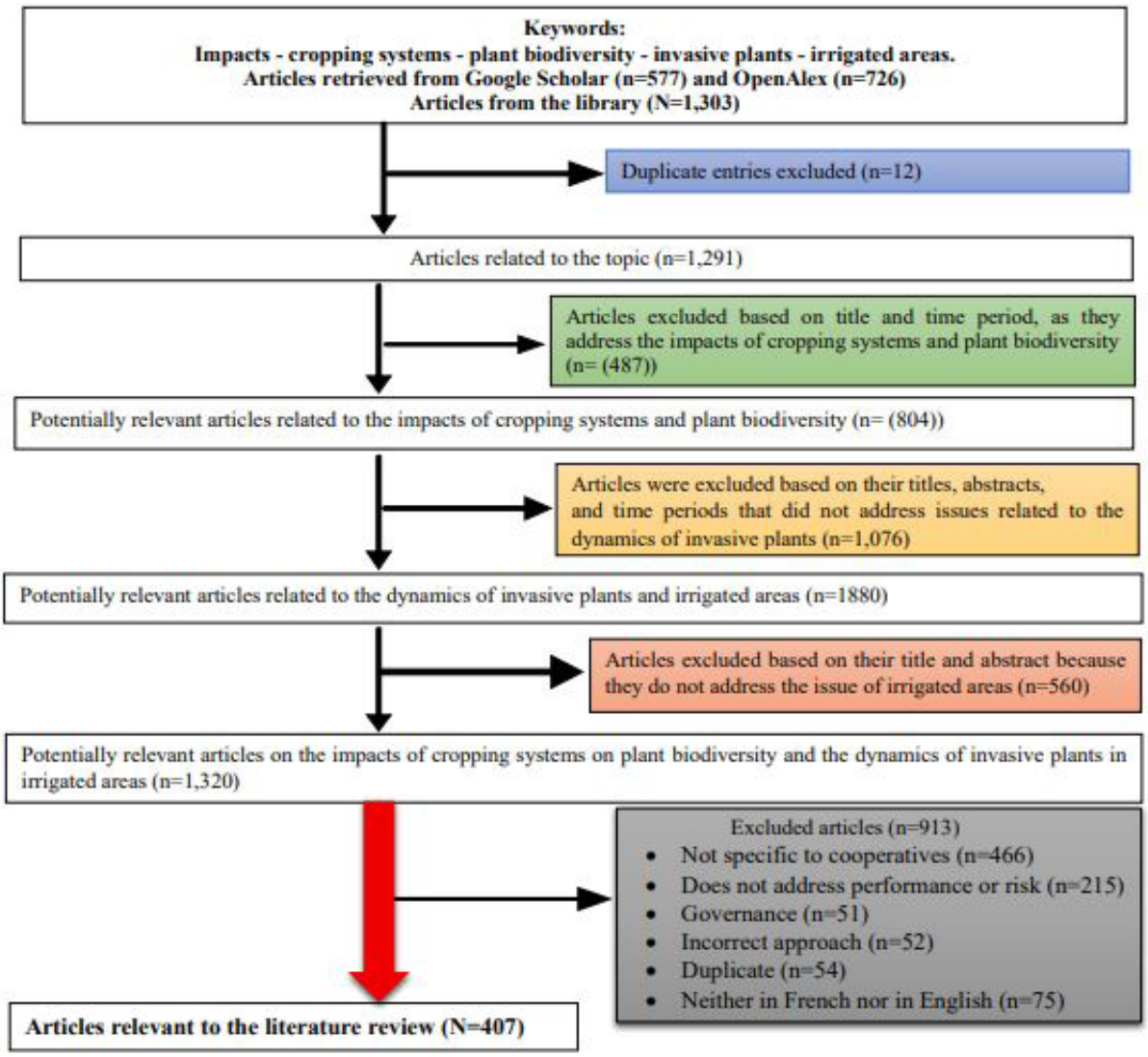


Figure 1: Flowchart of the systematic literature review

included articles. Figure S1 provides a full description of the methods used in this investigation.

Data analysis

Trends over time in keywords and themes, the productivity and impact of articles, and the relevance of scientific journals.

Firstly, this analysis covered several dimensions, which were examined using the R software and VOSviewer:

- Quantitative trends in scientific output by year;
- Analysis of scientific disciplines;
- Interdisciplinary interactions concerning invasive plants;
- Analysis of institutional linkages;
- Analysis of author linkages;
- Analysis of country linkages;
- Principal Component Analysis (PCA);
- Analysis of keywords and, more specifically, the co-occurrence of keywords over the entire period (2010–2025) enabled the visualisation of conceptual associations and the structure of the research field.

Subsequently, a systematic review of the literature was conducted based on the final corpus of 407 articles. This qualitative analysis aimed to synthesise specific knowledge on the impacts of cropping systems on plant biodiversity and the dynamics of invasive plants in irrigated contexts.

- **Historical Analysis**

A historical analysis was conducted to understand the trends over time in research into the impacts of cropping systems on native plant biodiversity and the dynamics of invasive species in irrigated areas between 2010 and 2025.

- **Analysis of bibliographic links/institutions**

Two articles are said to have a bibliographic link when they share at least one reference cited in their respective bibliographies or reference lists (Milard, 2013).

- **Keyword analysis**

Keyword analysis aims to highlight the conceptual structure of a research field by drawing on a network of term co-occurrences. This method makes it possible to map and group terms extracted from keywords, titles or abstracts within a bibliographic collection (Milard, 2013).

RESULTS AND DISCUSSION

Trends in the volume of scientific output by year

In total, 407 articles were selected for analysis. The analysis shows that the number of scientific articles on the impacts of cropping systems, plant biodiversity and the dynamics of invasive plants in irrigated areas increased between 2010 and 2025. However, scientific output has fluctuated over this period, although the overall trend is upward, with interest having grown particularly in recent years, as evidenced by the peak of 127 articles in 2024 (Figure 2).

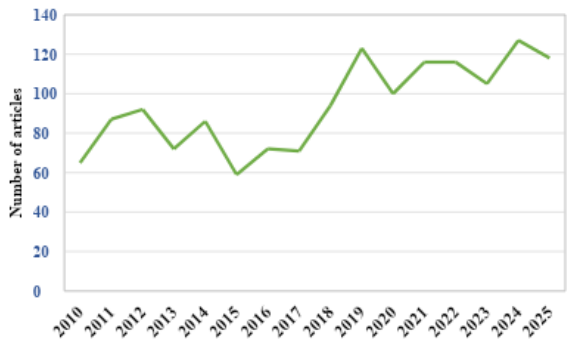


Figure 2: Trends in scientific output, 2010–2025

Analysis of scientific disciplines

An analysis of the 407 scientific publications reveals highly interdisciplinary research, structured around several interconnected disciplinary areas. The core of the work lies at the intersection of agronomy (covering cropping practices), plant biology and ecology (covering the mechanisms of biodiversity and invasions). This foundation is enriched by contributions from genetics and molecular biology, which are essential for understanding the evolution of herbicide resistance, as well as soil science and biogeochemistry, which shed light on the impact of inputs. The whole is underpinned by economic and socio-economic sciences, which explain management decisions, and supported by mathematical, computational and cartographic tools for modelling and spatial analysis. This disciplinary diversity reflects the intrinsic complexity of the subject under study: managing irrigated agroecosystems requires balancing production with conservation. The predominance of agronomic and biological themes confirms the focus on practical interactions with biodiversity. However, the growing integration of molecular and digital approaches points to a trend towards more refined and predictive research. Finally, the inclusion of the humanities and modelling tools highlights that solutions must be technically effective, economically viable and spatially explicit, aiming for the sustainable and integrated management of irrigated areas in the face of the challenges of encroachment and erosion of plant diversity (Figure 3).

The concepts and key terms put forward by the various authors, together with the explanatory factors identified, form the basis of our study

Concepts and key terms put forward by various authors

In this study, to avoid any confusion regarding the key concepts, we offer clear definitions of the subject matter, drawing on various authors' proposals:

Impacts: This term refers to all the effects, concrete or abstract, direct or indirect, positive or negative, associated with a particular event, development, action or initiative, on a given phenomenon (Frimousse & Peretti, 2020). In this study, it refers more specifically to the favourable or unfavourable, positive or negative effects of cropping systems on plant diversity and on the behaviour of invasive plant species within irrigated areas in the study area.

Growing systems: A cropping system refers to the methods and techniques used to cultivate the land and produce crops. It is defined by the combination of

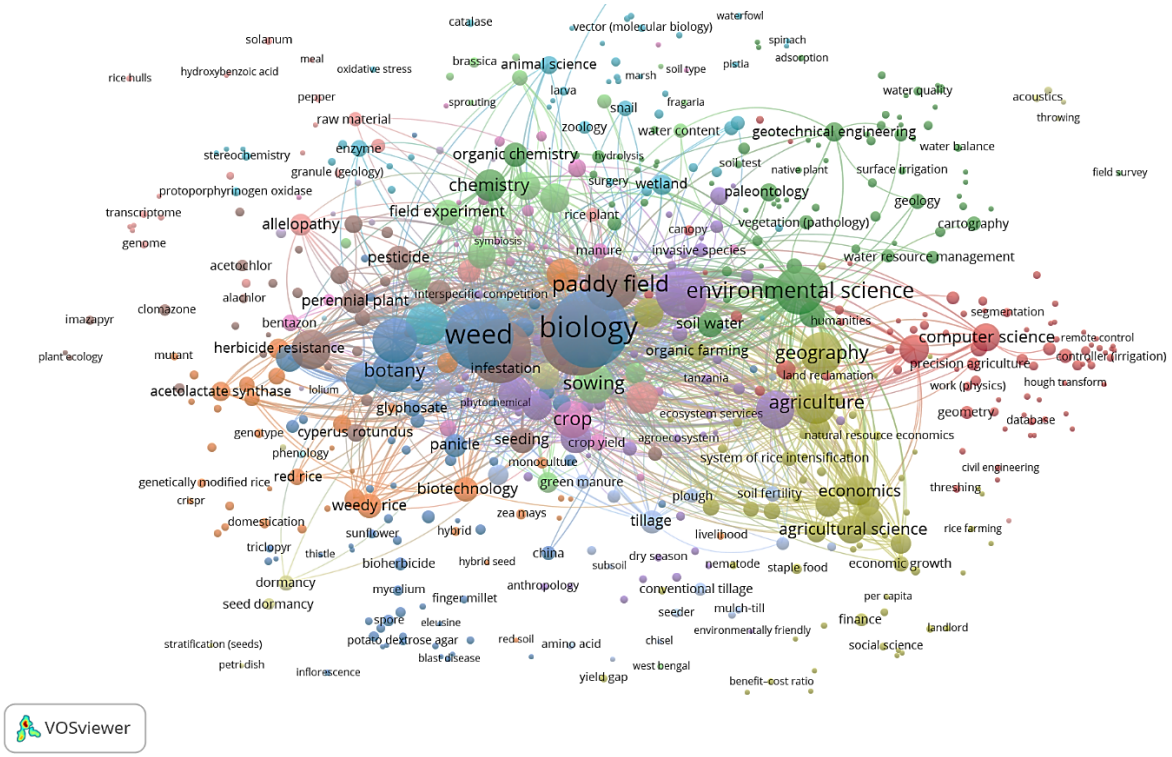


Figure 3: Analysis of scientific disciplines

technical practices applied to plots cultivated similarly and is characterised primarily by the following:

• The types of crops grown and their sequence over time (classification by system groups);

• The techniques used for each crop, in particular, the choice of varieties (Meynard, 2001).

• Plant biodiversity: This refers to the variety of plants found in an ecosystem, including genetic diversity within species, the number of different species, and the diversity of plant communities (Garon *et al.*, 2013).

Dynamic: According to Malavoi and Souchon, dynamics is the study of change (in all its forms) in relation to the forces that cause it and the corresponding forms of energy: it thus aims to provide an explanation rather than a mere description (Malavoi & Souchon, 1996). In the context of our study, 'dynamics' refers to the overall changes that have taken place in our study area, the factors responsible for them, and the resulting consequences over different time periods in relation to the socio-economic activities of local communities.

Invasive plants: An invasive (proliferating) plant is defined as 'any species which, following the removal of natural barriers to its proliferation, exhibits a competitive advantage enabling it to spread rapidly and colonise new areas within its ecosystem, where it becomes a dominant population. (Valéry *et al.*, 2008). This definition, which is widely accepted in the literature, serves as a reference for our study.

Irrigated area: According to Ostrom and Benjamin, an irrigated system consists of:

• A physical infrastructure (water source), on which several farmers depend for their water supply;

• A distribution network and means of accessing the resource (small downstream canals, pipes, etc.);

• A set of rules governing its operation (membership of the system, permitted actions, information sharing, sanctions and rewards) (Hanafi *et al.*, 2013; Rey *et al.*, 1996; Sow 2025).

Based on this definition, the irrigated area is, in our study, understood as an organised system of infrastructure that ensures the conveyance of water from its source to the cultivated plots requiring irrigation.

Les facteurs explicatifs sur la thématique concernée

Irrigated cropping systems, often characterized by agricultural intensification and monoculture, exert significant pressure on plant biodiversity. The increased use of chemical inputs (herbicides and fertilizers) eliminates non-target wild species, while the simplification of agricultural landscapes (fewer fallow fields, hedgerows, and diversified crops) homogenizes habitats. Furthermore, changes in the water regime caused by irrigation alter adjacent natural ecosystems, such as wetlands and riparian forests, leading to the reduction and impoverishment of local plant communities and the loss of species adapted to non-irrigated conditions.

Paradoxically, this simplification and disruption of the environment create ideal conditions for the emergence and dominance of invasive plants (weeds or invasive alien species). The constant supply of water and nutrients (fertilizers) supports the rapid growth and competitiveness of these opportunistic species. The repeated use of herbicides exerts strong selective pressure, favoring the emergence of resistant weed populations that are even more difficult to control. Furthermore, irrigation canals and ditches serve as effective pathways for spread,

allowing these plants to rapidly colonize new plots within the irrigated area.

Ultimately, irrigated areas are agricultural environments that are less diverse and more vulnerable to infestations. The resulting intensification takes a dual ecological toll: on the one hand, a drastic decline in native plant biodiversity, and on the other, increased proliferation of invasive plants that directly compete with crops for resources. To mitigate these impacts, it is essential to adopt agroecological practices that incorporate more diversified water and crop management, reduce dependence on chemical inputs, and prioritize the conservation of remaining natural habitats.

An analysis of the listed scientific journals reveals that research on invasive plants in irrigated areas relies primarily on a disciplinary network centered on agronomy and weed science (Weed Science, Agronomy). These technical disciplines provide fundamental knowledge on weed biology and control methods in cropping systems. However, the proposed theme, which links the impacts of cropping systems on biodiversity and the dynamics of invasions, requires moving beyond this technical framework. A truly interdisciplinary approach emerges by integrating crop sciences (Australian Journal of Crop Science), plant pathology (Plant Disease), and sustainability sciences (Sustainability). This convergence is necessary to understand the complex interactions between agricultural practices, water management, agroecosystem health, and the conservation of functional biodiversity. Thus, invasive success can be explained by a network of agronomic, ecological, and pedological factors, the joint analysis of which is essential for the agroecological management of irrigated areas (Figure 4).

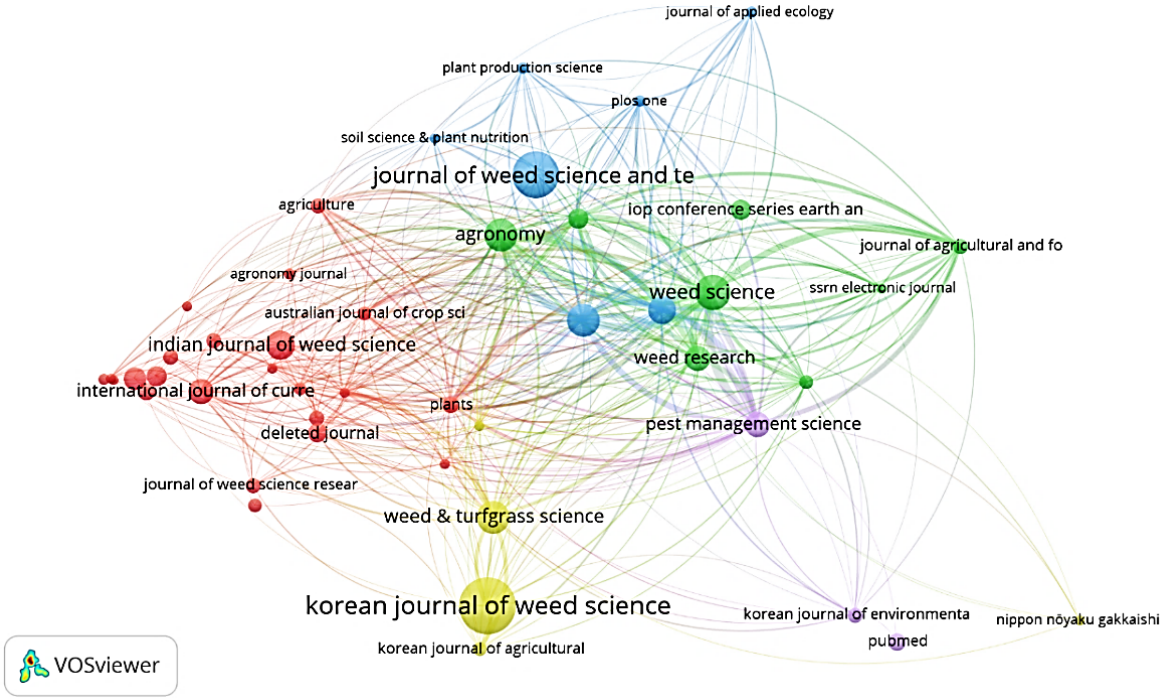


Figure 4: Interdisciplinary interactions surrounding invasive plants: A network of conceptual and sectoral relationships

Analysis of Institutional Linkages

The bibliographic linkage analysis by institution presented in Figure 5 illustrates the relationships between articles based on the bibliographic references they share. This analysis reveals a dense and complex institutional network centered on the impacts of cropping systems, plant biodiversity, and the dynamics of invasive plants in irrigated areas.

Numerous academic and scientific institutions from various regions of the world are involved, including universities, research centers, and international organizations. University Putra Malaysia (UPM) has emerged as a key hub, serving as a strategic hub connecting research centers in Asia, the Americas, and, to a lesser extent, Europe. This centrality is not only quantitative (number of links) but also qualitative: UPM appears to orchestrate the synthesis of knowledge between fundamental research in plant ecology (led by actors such as the Chinese Academy of Sciences or Kyoto University) and applied research in the agronomy of irrigated systems (conducted by institutions such as Nanjing Agricultural University, UC Davis, or Bangladesh Agricultural University).

This unique positioning enables it to play a pivotal role in coordinating transdisciplinary research efforts, integrating agronomy, ecology, social sciences, and water management to address the complexity of interactions between farming practices, biodiversity, and biological invasions.

Among the partners most closely affiliated with the UPM are:

- Banaras Hindu University and Virginia Tech;
- Bangladesh Agricultural University;
- China Agricultural University;

- Huazhong Agricultural University;
- Jiangsu University;
- Kyushu University;
- Nanjing Agricultural University;
- Punjab Agricultural University;
- South China Agricultural University;
- Tribhuvan University;
- University of Arkansas at Fayetteville;
- University of Bonn;
- University of California, Davis;
- University of the Ryukyus;
- Yangzhou University.

Clusters of institutions with complementary expertise revolve around this core network, reflecting both thematic and geographic specialization.

- A first East Asia/Pacific cluster (China Agricultural University, Huazhong Agricultural University, University of the Ryukyus) focuses on the challenges of intensive irrigated areas, combining biotechnology, fertility management, and weed control.
- A second South Asia/America cluster (Banaras Hindu University, Bangladesh Agricultural University, University of Arkansas, Punjab Agricultural University) focuses more on smallholder systems and the socio-economic challenges related to sustainability. On the periphery of the network, development and public policy organizations, such as the Food and Agriculture Organization (FAO), the USDA, the Rural Development Administration (Korea), and Embrapa, enrich the network by bringing perspectives on large-scale implementation, technology transfer, and agricultural policy formulation.

This illustrates how research on a specific environmental issue necessarily draws on a mosaic of expertise distributed across the globe.

While this mapping demonstrates robust international collaboration, it also highlights significant disparities. Africa is notably underrepresented as a hub of knowledge production within this network, which constitutes a critical gap given the importance and vulnerability of irrigated areas on the continent. Similarly, the limited presence of French-speaking and Latin American institutions (apart from Embrapa) suggests a certain linguistic and cultural homogeneity in the dominant literature.

For this research to be truly transformative, it is imperative to strengthen the central role and coordinating capacity of institutions in the Global South, and to more systematically integrate local knowledge and neglected agroecological contexts. The future of this field of research lies in its ability to evolve from a collaborative network into a truly equitable and inclusive knowledge ecosystem, capable of producing solutions tailored not only to agronomic and ecological challenges, but also to the imperatives of cognitive justice and resilient development on a global scale.

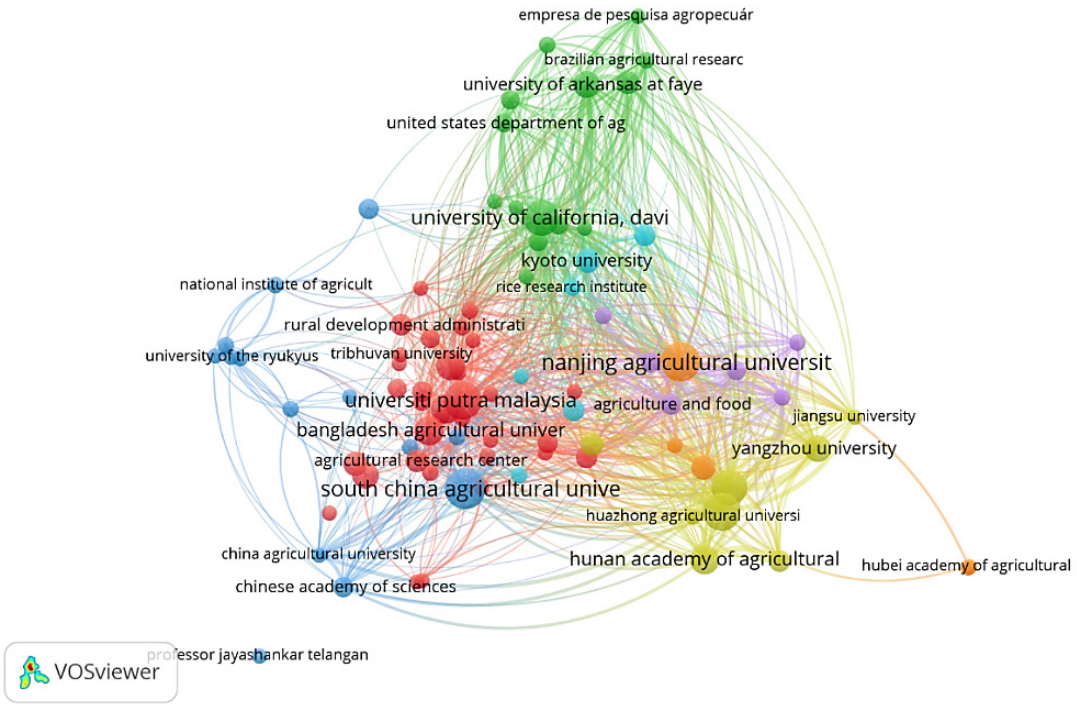


Figure 5: Primary institution based on search criteria

Analysis of blends by author

Figure 6 below illustrates the relationships among authors working on this specific topic. This list of authors reveals a network of international collaborations focused primarily on the study of the agronomic and ecological impacts of irrigated systems. Several pairs or small groups of authors stand out, suggesting close collaborations. This list of authors, ranging from (Kim, 1992) or (Zhang *et al.*, 2024), illustrates the gradual development of an international and multidisciplinary body of knowledge. Pioneering

figures such as (Kim, 1992) or (OhDo *et al.*, 2002) laid the groundwork, while researchers like (Chauhan *et al.*, 2010), a world-renowned specialist in rice weeds.

The most central researchers include:

• Structured the field around integrated management in irrigated systems (Shukor Juraimi *et al.*, 2013);

• Confirmed that research is concentrated in major irrigated areas, where the loss of diversity and the spread of invasive species are most pronounced (Karim *et al.*, 2004);

• Appear to be linked to studies on plant composition and biological invasions in these agroecosystems (Huang *et al.*, 2018).

The strong Asian presence (Karim *et al.*, 2004; Kong *et al.*, 2011; Lin *et al.*, 2006; Wada, 2004) confirms that research is concentrated in the main areas of irrigated agriculture, where pressures on biodiversity and plant invasions are most acute. The evolution of research priorities is marked by a diversification of approaches. Following a descriptive phase, the work of (Kong *et al.*, 2011) on allelopathy and that of (Adhikari *et al.*, 2020) on system dynamics introduced more mechanistic ecological perspectives.

Recent publications by authors such as (Liu *et al.*, 2023) or (Farooq *et al.*, 2022) highlight the integration of contemporary issues, such as adaptation to climate change and the resilience of agroecosystems. The recurrence of certain names with suffixes (Khanh *et al.*, 2005; Lin *et al.*, 2006) attests to the productivity of active research teams, including collaborative networks.

The geographic diversity of the authors reflects the global

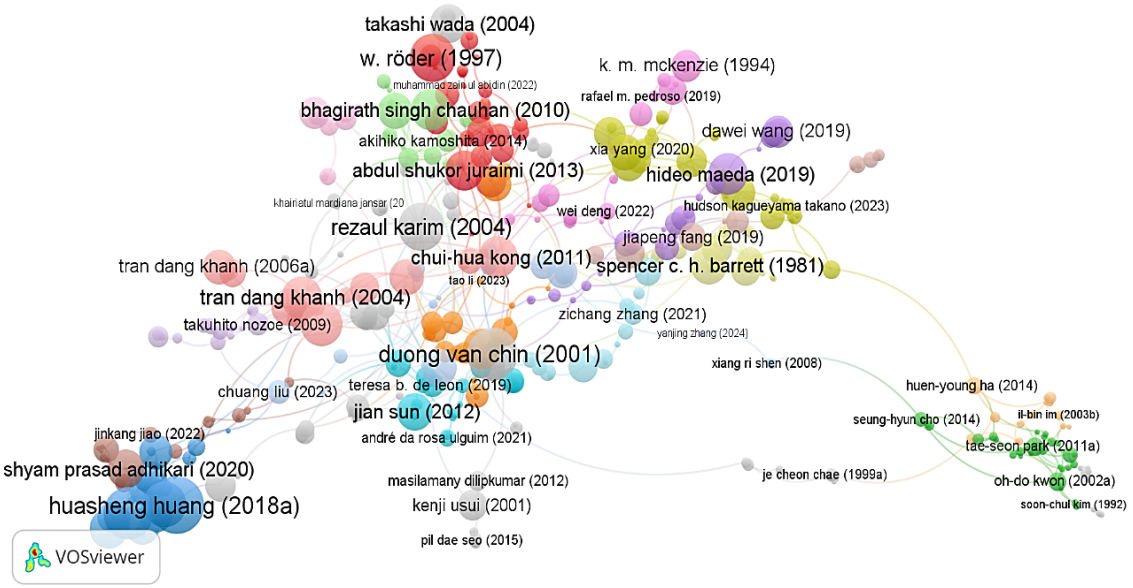


Figure 6: Leading authors based on search criteria

significance of issues related to agricultural intensification and ecological resilience. This list appears to be taken from a collective publication, perhaps a special issue of a journal or the proceedings of a conference, dedicated to the sustainability of irrigated areas. To refine the analysis, a targeted bibliometric study would help confirm the scientific standing of each author and map the co-publication networks in this interdisciplinary field, at the intersection of agronomy, plant ecology, and water management.

Analysis of linkages by country

An analysis of the countries on the list highlights several key geographic regions for studying the effects of irrigation on biodiversity and plant invasions. The analysis identifies several key geographic regions for studying the impact of irrigation. In East and Southeast Asia (China, Vietnam, Japan, etc.), intensive irrigation is dominated by rice cultivation. Other important regions include the Middle East (Saudi Arabia, Iran), temperate Europe (Hungary, United Kingdom), South America (Brazil), and Oceania (Australia). Study criteria include irrigation intensity and method, crop types, input use, and climatic context. In these irrigated areas, common effects are observed: a decline in native biodiversity due to habitat homogenization, the emergence of crop-associated weeds (Echinochloa in rice paddies), and the proliferation of invasive species favored by the constant availability of water (Typha). Concrete examples illustrate these problems around the world, such as the spread of Parthenium in South Asia or the degradation of Brazil's Cerrado. The key countries (China, India, the United States, Japan, and Malaysia) share common dynamics despite their geographical differences; they exhibit similar dynamics in irrigated systems, create dispersal corridors for invasive species, and generate ecological stress (salinization). Comparing these cases, for example, between intensive rice farming systems or between arid regions allows us to draw lessons for sustainable management aimed at reconciling food security with the preservation of biodiversity.

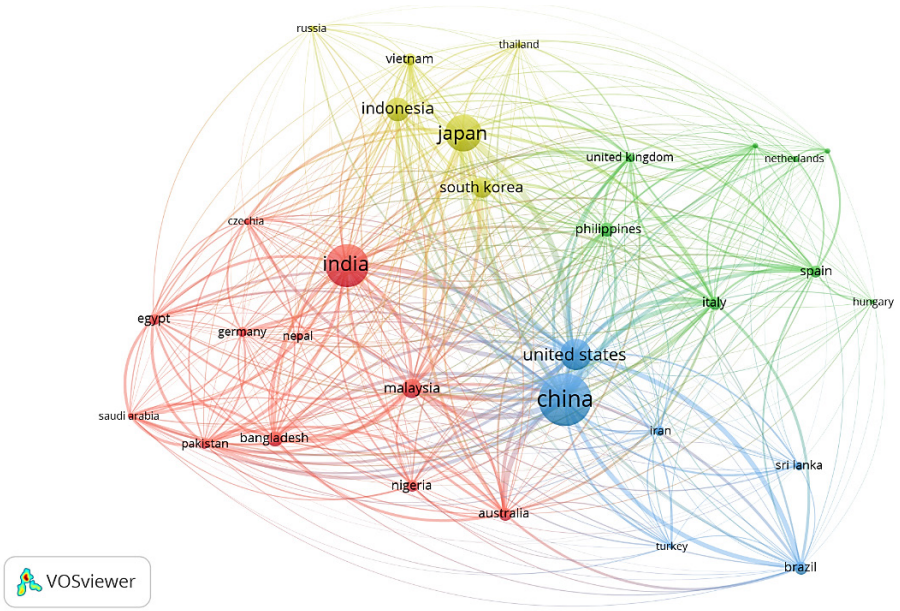


Figure 7: Top countries based on search criteria

Keyword Analysis

Factor Analysis (FA) of the keywords reveals a strong lexical structure centered on the topic under study. Dimension 1, which alone accounts for 61.44% of the variance, constitutes the primary axis of discourse organization. It most likely contrasts, on one side, terms associated with intensive farming systems (linked to monoculture, chemicals, or yield optimization) and, on the other, those related to agroecological or diversified practices (such as crop rotation or cover crops). This axis thus clearly reflects the gradient of agricultural intensification as a determining factor explaining lexical variations in discourses on biodiversity and invasive plants. The accumulation of nearly 90.16% of the information across the first two axes ensures a robust interpretation. Dim.2 (28.72%) provides a crucial nuance by capturing another distinguishing factor, potentially linked to the specific environmental constraints of irrigated areas, such as water conditions (drainage, salinity) or soil characteristics. Thus, the dynamics of invasive plants and their impacts on plant biodiversity are lexically described through two main lenses: crop management practices for axis one (1) and abiotic factors of the irrigated environment for axis two (2), confirming the multifactorial nature of the ecological processes at play. The table below summarizes the results of the keyword analysis:

Table 1: Summary of the values and contributions of the most frequently used keywords

	Dim.1	**Dim.2**
Equity	1,84	0,86
Contribution by category (%)	61,44	28,72
Sum of contributions from the research areas (%)	61,44	90,16

Principal Component Analysis (PCA) shows that two main axes structure the impact of cropping systems on the flora.

The first axis, Dim.1, is the major factor, primarily explaining the variation associated with the "Overall impact of cropping systems" (43.99%) and "Biotic and agronomic factors" (41.45%). This axis likely contrasts intensive systems with more extensive or diversified systems, indicating that the choice of cropping system (rice cultivation and vegetable farming) is the primary ecological determinant. It defines the basic conditions that influence both resident plant biodiversity and the pressure from invasive plants.

The second axis, Dim.2, reveals an independent dimension, dominated (84.65%) by direct "anthropogenic and agronomic factors" (management practices, inputs). This means that the intensity of human interventions (type of irrigation, fertilization, tillage) constitutes a distinct lever of action from the type of system. Consequently, the dynamics of invasive plants in an irrigated area result from the interaction between the ecological framework defined by the cropping system (Axis 1) and the selection filter imposed by daily management practices (Axis 2). Intensive management can thus favor invasive species even in a system that is, in principle, conducive to biodiversity.

The table below summarizes the correlations between the keywords:

Table 2: Summary of the correlations between the keywords of the first two (2) principal components identified by PCA

	Dim.1	**Dim.2**
Anthropogenic and agronomic factors	14,55	84,65
Biotic and agronomic factors	41,45	11,14
Impact of cropping systems	43,99	4,21

The results of the PCA analysis of keyword contributions reveal that research on the impacts of cropping systems in irrigated areas is organized around two complementary

dimensions.

First, axis one (1) (Dim.1) encompasses direct agronomic issues and symptoms observed in the field, with significant contributions from "Phyto-toxicity" (13.19%) and "Rice infested with weeds" (13.05%). This first axis therefore addresses the immediate effects of farming practices, particularly chemical stress and plant competition, which directly affect biodiversity and promote the proliferation of invasive species such as Panicum.

Next, axis two (2) Dim.2, dominated by "Agro-ecosystem" (22.68%), "Panicum" (5.44%), "Transplantation" (11.60%), and "Monoculture" (15.01%), represents the systemic and structural approach to research. It examines the root causes of changes in biodiversity by analyzing the very organization of agricultural systems. Monoculture, combined with practices such as transplantation, simplifies the irrigated agro-ecosystem and alters its ecological functioning, creating conditions conducive to the dynamics of invasive plants. Thus, scientific studies explicitly link structural cropping system choices (Dim. 2) to their concrete manifestations on plant biodiversity and symptomatic invasion (Dim. 1).

Table 3 provides a detailed summary of the contributions of the keywords used in the scientific publications studied:

Table 3: Summary of the contributions of keywords used in scientific publications

	Dim.1	Dim.2
Transplanting	2,70	11,60
Phytotoxicity	13,19	6,85
Weed-infested rice	13,05	7,36
Monoculture	3,01	15,01
Agroecosystem	0,06	22,68
Panicum	4,92	5,44

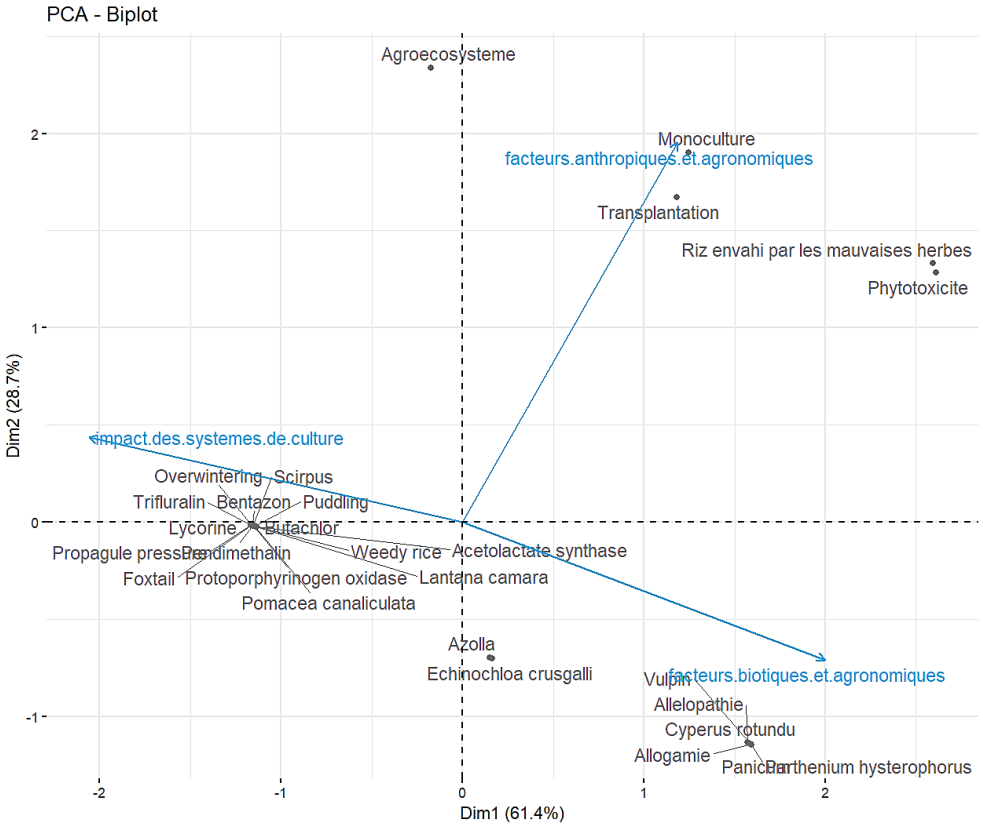


Figure 8: Co-occurrence analysis of keywords

The co-occurrence analysis of keywords, structured using PCA, reveals that the impacts of cropping systems on plant biodiversity and the dynamics of invasive plants in irrigated areas are primarily organized along two axes of influence:

1. Axis one (1) (61.4%) of the variance clearly contrasts anthropogenic and agronomic factors (such as transplanting, phytotoxicity, and puddling) with the presence and proliferation of major weeds (Echinochloa crus-galli, Cyperus rotundus). This demonstrates a direct causal link: farming practices alter the ecosystem and select a specific spectrum of invasive flora, often at the expense of natural plant diversity.

2. Axis two (2) (28.7%) highlights the differentiation between the specific impacts of management systems. On one hand, there are complex interactions such as allelopathy, allogamy, and biotic regulators (Azolla, Pomacea canaliculata), which represent ecological mechanisms influencing population dynamics.

On the other hand, factors such as propagule pressure and the winter survival of species such as Scirpus illustrate how the characteristics of the irrigated system (water continuity, tillage) promote the persistence and spread of undesirable plants.

In summary, this analysis highlights that the dynamics of plant invasions result from a close interaction between anthropogenic management pressures and ecological processes intrinsic to the irrigated environment.

Discussion

The positive trend in scientific output regarding the impacts of cropping systems on plant biodiversity and the dynamics of invasive plants in irrigated areas between 2010 and 2025 reveals a marked increase; this period accounts for 93.93% of all articles identified during the 2010–2025 timeframe. This trend reflects a growing interest among the scientific community in this issue, set against a global backdrop of climate change and increased pressure on agricultural resources. It thus underscores the need to develop sustainable management strategies to preserve plant biodiversity and mitigate the effects of invasive species. This recent surge can be attributed in particular to the international recognition of the need to strengthen food security in vulnerable regions, particularly in Africa and Asia, where rice is a strategic crop (Janin *et al.*, 2025). The multidisciplinary nature of the research is illustrated by the involvement of 870 scientific disciplines, primarily focused on agronomy, plant biology, molecular biology, biogeochemistry, cartography, genetics, horticulture, soil science, and ecology. The need for integrated management of irrigated areas, taking into account the interactions between cropping systems, plant biodiversity, and invasive plants, and the development of sustainable management strategies for cropping systems, aimed at reducing negative impacts on plant biodiversity and preventing biological invasions. Certain invasive plant species can increase the resilience of ecosystems to climate change and land-use changes (Tassin & Kull, 2015). Current studies focus primarily on the negative impacts of invasive plants, but it is important to also consider the potential positive impacts of certain invasive species (Richardson *et al.*, 2000). It is necessary to strengthen research on the ecological and evolutionary mechanisms underlying biological invasions to develop more effective management strategies (Jeon & Kim, 2017).

Network analysis of institutions shows that University Putra Malaysia (UPM) is at the center of a global network of scientific collaboration, including major Asian institutions such as Hunan Agricultural University (China), the Chinese Academy of Sciences (China), and Nanjing Agricultural University (China), as well as partners in Europe (Hungary), Africa (Nigeria), and Kyoto University (Japan). This structure illustrates the geopolitics of agricultural research, where China and Southeast Asian countries dominate scientific output and agricultural innovation (Martins *et al.*, 2021; Oliveira Neto *et al.*, 2020). These collaborations make it possible to pool expertise and develop drought-resistant crop varieties, tailored water management models, and technological innovations such as irrigation monitoring sensors and decision-support tools (Cho *et al.*, 2003; Panda *et al.*, 2019).

The country-by-country analysis confirms this trend, with China, the United States, India, Japan, Vietnam, and Malaysia serving as the central hubs of the global scientific network. This structure highlights transcontinental collaboration organized around thematic research programs, particularly those examining the influence of agricultural systems on plant biodiversity and the spread of invasive species. This research contributes to a more nuanced understanding of ecological mechanisms and fosters the emergence of innovative approaches for the sustainable management of natural resources. These scientific interactions are of crucial importance in adapting agricultural practices to the effects of climate change, particularly in arid and semi-arid regions. For example, the hydro-agricultural developments in the Lake Chad basin demonstrate the strategic importance of water management in these vulnerable contexts (Humblot, 2016; Ihcène, 2014; Bouras, 2021; Barbier, 2009).

Among the most cited authors identified in the author analysis are Abdul Shukor Juraimi, Rezaul Karim, and Huasheng Huang, who occupy central positions in the network. Their high scientific visibility suggests a significant contribution to agricultural research (agronomy), particularly in contexts related to cropping systems, plant biodiversity, the dynamics of invasive plants, and irrigated areas. However, few African authors appear clearly among the most cited in this map, which may reflect an underrepresentation of researchers from the continent in international databases or in high-impact publications. This observation underscores the importance of enhancing the visibility of African scientific work, particularly that conducted in specific agroecological contexts such as that of Niger.

The Principal Component Analysis (PCA) of the keywords reinforces this interpretation by revealing two major axes that together explain the variables. "Anthropogenic and agronomic factors" contribute significantly to axis Dim.2 (84.65%), suggesting that this second axis is strongly shaped by decisions regarding crop selection, resource management, and land use. In contrast, the variables "Biotic and agronomic factors" (41.45%) and "Impact of cropping systems" (43.99%) dominate axis Dim.1, which explains 61.44% of the total variance, with respective contributions of 41.45% and 43.99%. These results indicate that this axis primarily reflects a gradient of agricultural performance, centered on the efficiency and impact of cropping systems.

A similar study conducted by (Habbib, 2017; Basset-Mens, 2015; Dedieu *et al.*, 2006) also used PCA to analyze the factors influencing cropping systems. Both studies identified anthropogenic and agronomic factors as a major axis, but with different contributions (84.65%) and (72.1%). Biotic and agronomic factors are also present in both studies, but with different contributions (41.45%) and (56.3%). The impact of cropping systems is an important factor in both studies, but with different contributions (43.99%) and (65.2%).

Furthermore, the notable frequency of the keywords

"Transplantation," "Phytotoxicity," "Weed-infested rice," or "Monoculture" on axis Dim.2 indicates that the most recent research is focused on physiological processes and agronomic innovations aimed at optimizing irrigation efficiency in irrigated systems, particularly during critical stages of the rice growth cycle. This focus implies paying particular attention to crop and resource management strategies, as well as mitigating the environmental impacts associated with these practices. These observations corroborate the work of (Ahmadi & Bouman, 2013; Moinina *et al.*, 2018) which advocate techniques such as Alternate Wetting and Drying (AWD) to balance water conservation with stable yields. Both studies identify anthropogenic and agronomic factors as major driver, although their respective contributions differ by (61.4%) and (55.2%).

Biotic and agronomic factors also appear in both analyses, but with distinct contributions (exposure to invasive plants versus crop management).

The practices associated with anthropogenic and agronomic factors are similar in both studies (transplanting, monoculture, weed-infested rice, phytotoxicity, crop management, pesticide use, irrigation). This comparison builds on a similar study conducted by (Jarari, 2024), which also used Principal Component Analysis to examine the factors influencing cropping systems (Saporta, 2003).

CONCLUSION

This bibliometric analysis highlights a rapidly expanding, multidisciplinary, and internationally structured field of research, which nevertheless remains geographically unbalanced. It confirms that irrigated cropping systems exert significant pressure on plant biodiversity whilst creating conditions conducive to the proliferation of invasive plants. The results show that research centres primarily on two complementary dimensions: the degree of intensification of agricultural systems and the intensity of anthropogenic and agronomic factors.

In future, it seems necessary to strengthen research in the Global South, particularly in Africa, to harness local knowledge and promote more equitable scientific collaborations. Future work should explore the ecological and evolutionary mechanisms of biological invasions in greater depth, assess the long-term effects of agroecological practices, and consider the challenges of climate change, food security, and sustainable water management. In summary, this study provides a useful framework for guiding research policies and management strategies for irrigated areas towards a balance between agricultural production, biodiversity conservation, and the resilience of agroecosystems.

REFERENCES

Adhikari, S. P., Kim, G., & Kim, H. (2020). Deep neural network-based system for autonomous navigation in paddy field. *IEEE Access, 8*, 71272–71278. https://doi.org/10.1109/ACCESS.2020.2987642

Ahmadi, N., & Bouman, B. (2013). Riz et rizicultures, enjeux économiques, écologiques et scientifiques. *Cahiers Agricultures, 22*, 333–335. https://doi.org/10.1684/agr.2013.0665

Barbier, B. (2009). *Productivité de l'eau d'irrigation dans le bassin du fleuve Niger : Rapport définitif pour le BFP Niger.*

Basset-Mens, C. (2015). *Évaluation environnementale par l'Analyse de Cycle de Vie des systèmes de production agricole* [Mémoire d'habilitation à diriger des recherches, Université non précisée].

Bouras, E. H. (2021). *Besoin en eau et rendements des céréales en Méditerranée du Sud : Observation, prévision saisonnière et impact du changement climatique* [Thèse de doctorat, Université Paul Sabatier–Toulouse III & Université Cadi Ayyad]. HAL. https://theses.hal.science/tel-03616186v1

Chauhan, B. S., Migo, T., Westerman, P. R., & Johnson, D. E. (2010). Post-dispersal predation of weed seeds in rice fields. *Weed Research, 50*, 553–560. https://doi.org/10.1111/j.1365-3180.2010.00807.x

Cho, Y. S., Hidaka, K., & Mineta, T. (2003). Evaluation of white clover and rye grown in rotation with no-tilled rice. *Field Crops Research, 83*, 237–250. https://doi.org/10.1016/S0378-4290(03)00065-0

Dedieu, B., Servière, G., Madelrieux, S., Dobremez, L., & Cournut, S. (2006). Comment appréhender conjointement les changements techniques et les changements du travail en élevage ? *Cahiers Agricultures, 15*, 506–513. https://doi.org/10.1684/agr.2006.0028

El Gareh, F., & Oulamine, A. (2025). *Cartographie bibliométrique de la recherche sur l'exclusion sociale des jeunes NEET : Fragmentations disciplinaires, thématiques émergentes et perspectives interdisciplinaires* [Bibliometric mapping of research on youth NEET social exclusion: Disciplinary fragmentations, emerging themes, and interdisciplinary perspectives]. Zenodo. https://doi.org/10.5281/zenodo.15194426

El Jarari, M. (2024). Analyse par composantes principales des déterminants de la résilience des petits exploitants agricoles de la Vallée du Souss [Principal component analysis of the determinants of resilience among smallholder farmers in the Souss Valley]. *Finance, Auditing, Management and Economics, 16*. https://doi.org/10.5281/zenodo.13948487

Farooq, M., Nawaz, A., Nadeem, F., Bajwa, H. R., Salim, M. A., Rehman, A., & Ullah, A. (2022). Brown manuring and sorghum allelopathy affects weeds, soil health, and paddy yield. *Agronomy Journal, 114*, 3040–3051. https://doi.org/10.1002/agj2.21159

Frimousse, S., & Peretti, J.-M. (2020). Impact social positif et création de valeur. *Question(s) de Management, 27*, 91–130. https://doi.org/10.3917/qdm.201.0091

Garon, D., Guéguen, J.-C., & Rioult, J.-P. (2013). *Les cahiers de la biodiversité et Biodiversité : Évolution du monde vivant.*

Habbib, H. (2017). *Impacts des systèmes de cultures sur l'efficience d'utilisation de l'azote chez le blé et le maïs : Influence du travail du sol, des couverts végétaux d'interculture et de l'historique de fertilisation azotée* [Thèse de doctorat, Université de Picardie Jules Verne]. HAL. https://theses.hal.science/tel-03692930v1

Hanafi, S. (2013). *Approche d'évaluation de la performance des*

systèmes irrigués à l'échelle des exploitations agricoles : Cas du périmètre irrigué de Borj Toumi (vallée de la Medjerda-Tunisie) [Thèse de doctorat, Université non précisée]. HAL. https://theses.hal.science/tel-00920810v1

Himrane, M., Kadi, M., & Guedjali, A. (2024). Près de quatre décennies d'existence de la revue Les Cahiers du CREAD : Une analyse bibliométrique. *Les Cahiers du CREAD, 40*(1), 36. https://doi.org/10.4314/cread.v40i1.6

Huang, H., Deng, J., Lan, Y., Yang, A., Deng, X., & Zhang, L. (2018). A fully convolutional network for weed mapping of unmanned aerial vehicle (UAV) imagery. *PLOS ONE, 13*(4), Article e0196302. https://doi.org/10.1371/journal.pone.0196302

Humblot, P. (2016). *Impacts du changement climatique sur l'agriculture : Vers une meilleure prise en compte de la ressource en eau pour l'irrigation dans la modélisation bio-économique* [Thèse de doctorat, AgroParisTech]. HAL. https://theses.hal.science/tel-05129476v1

Ihcène, L. (2014). *Gestion de l'eau agricole et sécurité alimentaire dans le périmètre irrigué Guelma–Bouchegouf* [Mémoire de master, Université non précisée].

Janin, P., Fofiri Nzossie, E. J., Diakité, M. E., Thoreux, M.-S., Sacko, M., Koffi Kouamé, C., & Oliveira, S. R. (2025). *Insécurité alimentaire au Sahel central : Gouverner les crises alimentaires au Sahel central : Gérer les risques ou renforcer les acteurs ?* Production PASAS. AFD. https://hal.science/hal-05357788v1

Jeon, W., & Kim, K. (2017). Optimal weed control strategies in rice production under dynamic and static decision rules in South Korea. *Sustainability, 9*(6), Article 956. https://doi.org/10.3390/su9060956

Juraimi, A. S., Uddin, M. K., Anwar, M. P., Mohamed, M. T. M., Ismail, M. R., & Man, A. (2013). Sustainable weed management in direct seeded rice culture: A review. *Australian Journal of Crop Science, 7*(7), 989–1002.

Karim, R. S. M., Azmi, M., Man, B., & Sahid, I. B. (2004). *Weed problems and their management in rice fields of Malaysia: An overview.*

Khanh, T. D., Hong, N. H., Xuan, T. D., & Chung, I. M. (2005). Paddy weed control by medicinal and leguminous plants from Southeast Asia. *Crop Protection, 24*, 421–431. https://doi.org/10.1016/j.cropro.2004.09.020

Kim, S. C. (1992). *Weed ecology and effective weed control technology in direct-seeded rice* (pp. 230–260).

Kong, C. H., Chen, X. H., Hu, F., & Zhang, S. Z. (2011). Breeding of commercially acceptable allelopathic rice cultivars in China. *Pest Management Science, 67*, 1100–1106. https://doi.org/10.1002/ps.2154

Lin, D., Sugitomo, Y., Dong, Y., Terao, H., & Matsuo, M. (2006). Natural herbicidal potential of saururaceae (Houttuynia cordata Thunb) dried powders on paddy weeds in transplanted rice. *Crop Protection, 25*, 1126–1129. https://doi.org/10.1016/j.cropro.2006.02.004

Liu, C., Yang, K., Chen, Y., Gong, H., Feng, X., Tang, Z., Fu, D., & Qi, L. (2023). Benefits of mechanical weeding for weed control, rice growth characteristics and yield in paddy fields. *Field Crops Research, 293*, Article 108852. https://doi.org/10.1016/j.fcr.2023.108852

Malavoi, J. R., & Souchon, Y. (1996). Dynamique fluviale et dynamique écologique. *La Houille Blanche, 51*, 98–107. https://doi.org/10.1051/lhb/1996076

Martins, M. B., Agostinetto, D., Fogliatto, S., Vidotto, F., & Andres, A. (2021). Aeschynomene spp. identification and weed management in rice fields in Southern Brazil. *Agronomy, 11*(3), Article 453. https://doi.org/10.3390/agronomy11030453

Meynard, J. M. (2001). L'évolution et la conception de système de culture pour une agriculture durable. *Académie d'Agriculture de France, 10*.

Milard, B. (2013). *Quelles sociabilités derrière les références bibliographiques ? Citations et relations sociales. Socio-Logos.* https://doi.org/10.4000/socio-logos.2802

Moinina, A., Boulif, M., & Lahlali, R. (2018). *La culture de riz (Oryza sativa) et ses principaux problèmes phytosanitaires : Une mise au point sur la région du Gharb.*

OhDo, K. O. K., YongIn, K. Y. K., DoJin, L. D. L., HaeRyong, S. H. S., InJin, P. I. P., EulBae, K. E. K., & JaOck, G. J. G. (2002). Growth and yield of rice as affected by competitive period of resistant Monochoria vaginalis biotype to sulfonylurea herbicides. *Korean Journal of Weed Science, 22*.

Oliveira Neto, A. M., Guerra, N., & Noldin, J. A. (2020). Off-season management with herbicides as an alternative to reduce weed infestation in paddy rice production systems. *Planta Daninha, 38*, 1–8. https://doi.org/10.1590/S0100-83582020380100082

Panda, T., Mishra, N., Rahimuddin, S., Pradhan, B. K., & Mohanty, R. B. (2019). Distribution pattern and multifarious use of weeds in rice agro-ecosystems of Bhadrak district, Odisha, India. *Tropical Plant Research, 6*(3), 345–364. https://doi.org/10.22271/tpr.2019.v6.i3.045

Rey, J., Renault, D., & Lamacq, S. (1996). Can irrigation management learn something from industry? *La Houille Blanche, 51*, 70–74. https://doi.org/10.1051/lhb/1996091

Richardson, D. M., Pyšek, P., Rejmánek, M., Barbour, M. G., Panetta, F. D., & West, C. J. (2000). Naturalization and invasion of alien plants: Concepts and definitions. *Diversity and Distributions, 6*(2), 93–107. https://doi.org/10.1046/j.1472-4642.2000.00083.x

Rostaing, H. (1997). *La bibliométrie et ses techniques.* HAL. https://hal.science/hal-01579948v1

Saporta, G. (2003). *Analyse en composantes principales.* HAL. https://cnam.hal.science/hal-02507732v1

Sow, O. (2025). *Caractérisation de l'agriculture irriguée et analyse de ses impacts socioéconomiques et environnementaux dans la Commune de Keur Momar Sarr* (Région de Louga, Sénégal) [Mémoire de master, Université Assane Seck de Ziguinchor].

Tassin, J., & Kull, C. A. (2015). Facing the broader dimensions of biological invasions. *Land Use Policy, 42*, 165–169. https://doi.org/10.1016/j.landusepol.2014.07.014

Valéry, L., Fritz, H., Lefeuvre, J. C., & Simberloff, D. (2008). In search of a real definition of the biological invasion phenomenon itself. *Biological Invasions, 10*, 1345–1351. https://doi.org/10.1007/s10530-007-9209-7

Wada, T. (2004). *Strategies for controlling the apple snail Pomacea canaliculata (Lamarck) (Gastropoda: Ampullariidae) in Japanese direct-sown paddy fields*. JIRCAS. http://www.jircas.affrc.go.jp

Zhang, Y. J., Hu, J., Wang, C. B., Wang, Y. Q., Ji, M. L., Ma, F. Z., & Lu, Y. Q. (2024). Estimating global geographical distribution and ecological niche dynamics of Ammannia coccinea under climate change based on Biomod2. *Scientific Reports, 14*, Article 82164. https://doi.org/10.1038/s41598-024-82164-6

Appendices

Appendix 1: Overview of Methods

1. Extraction of information from the selected articles

- Authors' names;
- Type of approach used: quantitative or qualitative;
- Types of models used;
- Variables used.

Processing of the information obtained

Classification without further processing of the information

- List of authors;
- List of journals and magazines;
- List of keywords;
- List of models used;
- List of variables used;
- Classification of articles (C1) according to a qualitative and/or quantitative approach.

Classification and data analysis

- Frequency of journals;
- Frequency of years;
- Frequency of authors;
- Frequency of variables;
- Classification of journals by reputation, if relevant.

Analysis of potential biases in the data extraction conducted for the study

More extensive literature review on the impacts of cropping systems on plant biodiversity and the dynamics of invasive plants in irrigated areas

- Frequency of years;
- Occurrence of keywords across the entire literature review and by sub-period;
- Analysis of article co-citations;
- Frequency of collaborations among authors;
- Analysis of changes in the number of articles over time: number per year; Comparison of the results of the expanded extraction with those of the study: identification of potential selection biases.