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Extent and Impacts of *Typha domingensis* Pers. in the Agro-Ecological Zones of Southeastern Niger: The Case of Dallol Bosso, Dallol Maouri and the Korama Valley: A Bibliometric Synthesis

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A B S T R A C T

The wetlands and agro-ecological zones of southeastern Niger play a crucial role in the functioning of socio-ecological systems and the support of local livelihoods. Among invasive species, *Typha domingensis* Pers. is attracting increasing scientific interest due to its ecological, hydrological, and socio-economic impacts. This study conducts a bibliometric analysis of publications on *Typha domingensis* from 1993 to 2023, using the OpenAlex and Google Scholar databases. A total of 720 articles were selected for this analysis. The results show a marked increase in scientific output, rising from 1.25% of articles in 1993 to 12.78% in 2023, with disciplinary interest shifting from fundamental chemistry and biology to an interdisciplinary approach integrating ecology, hydrology, phytoremediation, and socio-economic dimensions. Emerging themes include invasion management, water and sediment remediation, wetland engineering, and impacts on agriculture and livelihoods, particularly in the context of the Lake Chad Basin and climate change. Analysis of institutional collaborations reveals an international network structured around North American, European, and Brazilian hubs, with a growing role for African actors. This finding can be used to guide future research and strategies for the sustainable management of wetlands.

Introduction

Wetland and agro-ecological zones of the Sahel occupy a strategic position in the functioning of socio-ecological systems, providing essential ecosystem services such as agricultural production, hydrological regulation, biodiversity conservation, and support for the livelihoods of rural populations (FAO, 2017; CBLT, 2019). In Niger, and particularly in the southeastern regions integrated into the Lake Chad Basin, these environments constitute key areas for irrigated agriculture, livestock production, and artisanal fisheries.

However, these ecosystems are increasingly facing growing anthropogenic and climatic pressures, among which the proliferation of invasive plant species is particularly significant.

Among these species, *Typha domingensis* Pers. has emerged as one of the most studied aquatic macrophytes due to its strong invasive potential in tropical and subtropical wetlands (Zedler & Kercher, 2004; Brix *et al.,* 2014). While some studies highlight its positive ecological functions—such as bank stabilization and nutrient uptake—an increasing body of research emphasizes the negative effects associated with its excessive proliferation, including alterations in hydrological regimes, reductions in aquatic biodiversity, and disruptions to agro-pastoral activities (Mitsch & Gosselink, 2015; Adam *et al.,* 2015). In West Africa, the rapid expansion of *Typha domingensis* is largely attributed to hydraulic infrastructures, water eutrophication, and changes in natural flood dynamics.

In southeastern Niger, several technical and scientific studies have reported the impacts of *Typha domingensis* on irrigated schemes, valleys, and floodplains, particularly through the obstruction of irrigation canals, the reduction of cultivable land areas, and the degradation of aquatic habitats (FAO, 2018; CBLT, 2020). Other works also underline the sanitary and socio-economic implications associated with water stagnation and the loss of access to natural resources, further increasing the vulnerability of local communities within a Sahelian context already marked by climate change and food insecurity (WHO, 2016; IPCC, 2022).

Despite the growing number of publications on *Typha domingensis* at both global and regional scales, the scientific literature remains fragmented and dispersed across multiple disciplines—including ecology, agronomy, hydrology, social sciences, and environmental management—and is unevenly distributed across geographical contexts. Studies specifically focusing on Niger, and particularly on the southeastern part of the country, remain relatively limited and poorly synthesized compared with research conducted in other Sahelian basins such as the Senegal River. This dispersion of knowledge complicates the identification of dominant research trends, emerging themes, and existing scientific gaps.

In this context, bibliometric analysis represents a relevant methodological approach for systematically and quantitatively examining the scientific production related to *Typha domingensis*. By mobilizing metadata from bibliographic databases, this method makes it possible to analyze the temporal evolution of publications, identify the main thematic areas, map collaboration networks among authors, institutions, and countries, and highlight underexplored research domains (Aria & Cuccurullo, 2017).

Applied to the issue of *Typha domingensis* in the agro-ecological zones of southeastern Niger, such an analysis contributes to structuring the current state of knowledge and provides a solid scientific basis for guiding future research and sustainable management strategies.

The general objective of this study is therefore to analyze, through a bibliometric approach, the evolution, structure, and orientations of the scientific production devoted to *Typha domingensis* Pers., with particular emphasis on Sahelian zones and southeastern Niger.

Materials and Methods

Data Collection

Several bibliometric databases exist, including Web of Science, Scopus, Google Scholar, and OpenAlex**.** For this study, the OpenAlex database (https://openalex.org/works) and Google Scholar (http://scholar.google.com) were selected because of their accessibility and extensive coverage of open-access publications.

OpenAlex, which relies on open data and infrastructures—particularly Crossref, RoR, ORCID, DOAJ, and Wikidata—provides an alternative to subscription-based databases such as Scopus (Priem *et al.,* 2022). Google Scholar complements this approach by integrating a wide variety of academic sources, including journal articles, conference papers, theses, and reports.

Data were collected using the **Publish or Perish** search engine through the following query: *(Invasive species AND impact on wetlands OR agriculture AND ecological impact).*

Data Analysis and Processing

For analytical purposes, the study period **1993–2023** was

divided into three phases corresponding to distinct socio-environmental contexts:

- **1993–2003:** Ecological and functional studies of wetlands
- **2004–2013:** Biological invasion and ecological management
- **2014–2023:** Socio-ecological, agroeconomic, and climate change perspectives

A total of **720 articles** were retained for the analysis.

Historical Analysis

A temporal analysis was conducted to examine the evolution in the volume of publications between **1993 and 2023** addressing the extent and impacts of *Typha domingensis* Pers. Dominant disciplinary fields were identified through the analysis of keywords.

Bibliographic Coupling Analysis

Bibliographic coupling identifies links between articles that share common references (Kessler, 1963). A bibliographic coupling network is obtained using the following general formulation:

- **RA:** the set of bibliographic references cited by document A
- **RB:** the set of references cited by document B
- **BC(A,B):** the bibliographic coupling strength between A and B
- **|RA ∩ RB|:** the number of shared references cited by both A and B

Concept Co-occurrence Analysis (Keywords)

Keyword analysis aims to reveal the conceptual structure of a research field by constructing a **co-occurrence network of terms**. This approach maps and clusters terms extracted from keywords, titles, or abstracts within a bibliographic collection (Kessler, 1963).
A co-word network is obtained using the following general formulation:

Let *i* and *j* be two terms or concepts, and *Dk* a document in the corpus:
Where:

- C(i,j) represents the number of co-occurrences between concepts *i* and *j* in a corpus of *N* documents.
- δi,k = 1 if term *i* appears in document *Dk*, otherwise 0.
- δj,k = 1 if term *j* appears in document *Dk*, otherwise 0.

Statistical Analyses

A Correspondence Analysis (CA) was conducted to highlight the relationships between the keywords cited in these publications and the three temporal periods (1993–2003, 2004–2013, and 2014–2023).

All analyses were performed using R software version 4.4.3**,** with the packages FactoMineR**,** factoextra**,** dplyr**,** and ggplot2.

Results and Discussion

Quantitative Evolution of Scientific Articles

The analysis shows that the number of scientific articles addressing the extent and impacts of *Typha domingensis* Pers. in the agro-ecological zones of southeastern Niger increased overall between 1993 and 2023. The proportion of articles rose from 1.25% in 1993 to 12.78% in 2023**.**

However, scientific production experienced fluctuations during this period, although the general trend remained upward, with a particularly strong increase in recent years. This is illustrated by the high number of publications recorded in 2023 (92 articles)**.** Previous years also show a steady progression, increasing from 9 articles in 1993 to 90 articles in 2021, reflecting the growing scientific interest in this topic (Figure 1).

Dominant Scientific Disciplines

The temporal overlay co-occurrence map (2004–2012) highlights an evolving trajectory of research on *Typha*, structured around a central scientific core dominated by biology, ecology, and environmental sciences, reflecting an integrated approach that considers the species as a major component of wetland ecosystems.

The earliest themes (2004–2006) are primarily oriented toward environmental chemistry, contamination, and bioaccumulation**,** reflecting an initial concern with aquatic pollution. The intermediate phase (2007–2009) marks a consolidation of knowledge through the

integration of biogeochemical cycles, including analyses of biomass, nutrients, and eutrophication, as well as comparisons of *Typha* with other aquatic macrophytes.

From 2010–2012, research themes diversified and expanded to include emerging topics such as constructed wetlands, environmental engineering, hydrology, biodiversity, and health, highlighting increasing interdisciplinarity. This evolution reflects growing recognition of the functional role of *Typha* as a nutrient regulator, pollution mitigation tool, and key element in the integrated management of wetland ecosystems, both natural and artificial, marking a phase of strong scientific maturity in this research field (Figure 2).

Evolution of Disciplinary Fields (1993–2023)

The temporal analysis of keywords for the 1993–2003 period shows a progressive and hierarchical evolution of research on *Typha*. Early research was dominated by fundamental chemical and biological approaches, representing approximately 30–35% of total occurrences during 1994–1997, primarily focused on soil and sediment chemistry, nutrients (particularly phosphorus), and basic biological processes such as germination and rhizome development**.**

The intermediate phase (1998–2000) appears as the most structurally significant within the network, accounting for nearly 40% of occurrences, and marked by the increasing prominence of the keywords ecology, biology, wetland, and environmental science, reflecting a shift toward an ecosystem-based interpretation of *Typha* as a key element in wetland functioning and biomass production.

The most recent phase of this period (approximately 2001–2002) represents about 25–30% of occurrences and is characterized by strong thematic and disciplinary diversification, with the emergence of agricultural hydrology, water quality, environmental engineering, biodiversity, and even health sciences, indicating a systemic perspective oriented toward sustainable management and ecosystem services.

The persistent centrality of the keywords Typha, wetland, ecology, and environmental science across all periods confirms the maturity of the scientific field while highlighting the increasing complexity of research issues. This complexity is particularly relevant for Sahelian contexts such as the Lake Chad Basin and Niger**,** where ecological, hydrological, and socio-environmental dimensions remain insufficiently integrated (Figure 3).

For the 2004–2012 period, the analysis indicates a strong structuring of research on *Typha*, centered on biology, ecology, and environmental sciences, which together account for approximately 45–50% of total occurrences, emphasizing an integrated ecosystem-based approach to the species.

The earliest themes (2004–2006), representing around 25–30% of occurrences, focus mainly on environmental chemistry, heavy metal contamination, organic matter, and bioaccumulation, reflecting initial concerns regarding aquatic pollution and chemical processes in wetlands.

The consolidation phase (2007–2009), accounting for approximately 30–35% of occurrences, reflects increased integration of biogeochemical cycles through studies of biomass, nutrients, eutrophication, and comparisons between *Typha* and other aquatic macrophytes, confirming its structuring role in aquatic ecosystems.

Finally, emerging themes (2010–2012), representing nearly 20–25% of occurrences, show strong disciplinary diversification, including constructed wetlands, environmental engineering, agricultural hydrology, biodiversity, and health sciences**,** indicating a shift toward nature-based solutions and integrated water management**.**

Overall, this dynamic highlights the growing recognition of *Typha* as a functional regulator of nutrients, a tool for environmental remediation, and a key component of both natural and artificial wetlands, at the center of contemporary environmental challenges (Figure 3).

The 2014–2023 period is dominated by ecological and biological approaches**,** with biology, wetland, macrophyte, and Typha occupying the core of the research network.

Studies emphasize the functional role of ***Typha*** in wetlands, particularly through species-specific investigations.
A major research axis concerns environmental chemistry and phytoremediation, illustrating increasing interest in the capacity of *Typha* to accumulate pollutants and

contribute to the remediation of water and sediments. At the same time, the development of constructed wetlands for wastewater treatment and nutrient management reflects a more applied orientation of research.

The temporal analysis reveals a gradual shift from fundamental studies toward integrated approaches focused on sustainability, biomass valorization, and climate change adaptation, confirming the interdisciplinary nature of research on *Typha* and wetland ecosystems (Figure 3).

Relationships Between Institutions

The institutional bibliographic coupling analysis made it possible to visualize relationships between articles sharing common references.

The results reveal a scientific network structure dominated by a few major hubs, particularly Brazilian universities and research centers, which play a central role in studies on *Typha* and wetlands. These hubs are closely connected with North American and European institutions, reflecting the influence of Northern countries in the methodological and theoretical development of the field. Furthermore, institutions from North Africa and the Middle East appear as intermediate actors, contributing to the gradual expansion of the collaborative research network.

Overall, the figure illustrates a growing dynamic of international collaboration, characterized by North–South partnerships and the interdisciplinary nature of research on ***Typha*** and wetland ecosystems (Figure 4).

Edaphic Factors Controlling the Proliferation of *Typha domingensis*

The analysis indicates that the density of *Typha domingensis* generally increases with improved edaphic conditions, particularly in fine-textured soils (clayey and clay-loam) characterized by neutral to slightly alkaline pH, moderate electrical conductivity, and high levels of organic matter, nitrogen, and phosphorus.

Very high densities of *Typha* are associated with the highest values of organic matter (5.6–6.3%), nitrogen (0.35–0.41%), and phosphorus (24.7–31.2 mg/kg). In contrast, sandy soils, which are poorer and more permeable, show lower nutrient concentrations and correspond to lower densities of ***Typha***.

Keyword Analysis Over Time

The results of the Correspondence Analysis (CA) of keywords used in scientific publications indicate that the first two axes account for 88.25% of the total information, with 46.88% explained by Axis 1 and 41.37% by Axis 2.

Indicator	Dim.1	Dim.2
Eigenvalue	1.41	1.24
Axis contribution (%)	46.88	41.37
Cumulative axis contribution (%)	46.88	88.25

Period 1993–2003

The dominant keywords during this period are mainly related to wetlands and aquatic vegetation, such as Wetlands (18.5%), Cattail (14.2%), Nutrient removal (12.6%), Primary productivity (10.8%), Aquatic vegetation (9.7%), and Water quality (8.9%).

This period appears to be characterized by a scientific focus on the ecological functions and ecosystem services of wetlands, particularly primary productivity, phytoremediation, and nitrogen dynamics. There is also noticeable interest in ecosystem recovery and restoration, as indicated by the keyword Restoration (4.78%) (Figure 6).

Period 2004–2013

The most frequent keywords during this period reflect a shift toward ecosystem management and dynamics under anthropogenic pressures, including Invasive species (16.9%), Wetland management (14.8%), Hydrology (12.4%), Ecosystem impact (11.6%), and Typha spp. (9.9%).

This phase highlights growing attention to the management of invasive species and human impacts on wetland ecosystems, as well as studies on vegetation dynamics and biodiversity within the context of land-use change (7%) (Figure 6).

Period 2014–2023

Recent publications show a prevalence of issues related to Typha domingensis and socio-economic pressures,

with keywords such as Typha domingensis (17.8%), Invasion (15.6%), Irrigation systems (12.9%), Agriculture (11.7%), Lake Chad Basin (9.8%), Climate change (8.6%), Ecosystem services (7.9%), and Livelihoods (6.5%).

This period reflects a broadening of the research field, incorporating not only the ecological impacts of Typha invasion, but also its implications for agriculture, food security, climate resilience, and ecosystem services.

Concerns regarding wetland degradation and adaptation to climate change are also emphasized (Wetland degradation: 5.6%; Adaptive management: 3.6%) (Figure 6).

The results of the bibliometric analysis on *Typha domingensis* Pers. in the agro-ecological zones of southeastern Niger reveal a significant evolution in scientific interest in this species over the period 1993–2023. The increase in the number of articles, rising from 1.25% in 1993 to 12.78% in 2023, reflects not only a quantitative expansion of research but also a qualitative maturation of the scientific field.

This upward trend is consistent with studies on macrophyte invasions in tropical and subtropical wetlands, where *Typha* plays a central role in ecological dynamics and the provision of ecosystem services.

Disciplinary Evolution and Interdisciplinarity

The temporal analysis of keywords and the co-occurrence map indicate that early research (1993–2003) was dominated by fundamental chemical and biological approaches. Keywords such as *phosphorus*, *rhizomes*, *germination*, and *soil chemistry* reflect interest in basic physiological and biogeochemical processes.

This phase aligns with pioneering studies on invasive macrophytes and their role in nutrient cycling and primary productivity in wetlands (Zedler & Kercher, 2004).
The intermediate period (2004–2012) is characterized by a consolidation of knowledge, with a disciplinary core centered on biology, ecology, and environmental sciences.
The emergence of themes such as eutrophication, biomass, and comparisons with other aquatic macrophytes reflects a systemic approach aimed at understanding *Typha* as an ecological regulator.

This trend is consistent with the expansion of integrated ecosystem studies in wetlands, which consider interactions between biogeochemistry, hydrology, and biodiversity (Mitsch & Gosselink, 2015).

The recent phase (2014–2023) reveals a notable disciplinary expansion. Research increasingly focuses on phytoremediation, constructed wetlands, environmental engineering, and the socio-economic impacts of ***Typha***.

The emergence of keywords such as climate change, livelihoods, and ecosystem services reflects a more applied and transdisciplinary orientation,

Integrating both ecological and socio-economic dimensions of biological invasions (MEA, 2005).

These findings indicate growing recognition of *Typha* as a strategic component for sustainable wetland management and the resilience of local communities facing environmental change.

Emerging Research Themes

Invasion Management and Biodiversity

Keywords such as invasive species, Typha spp., and wetland management indicate that research increasingly focuses on understanding the impacts of ***Typha*** on local biodiversity and aquatic ecosystems (Gopal, 1990).

Phytoremediation and Pollution Control

Interest in environmental chemistry and pollutant accumulation highlights the functional role of *Typha* as a tool for water and sediment remediation, particularly relevant in Sahelian contexts where water quality is critical (Vymazal, 2011).

Figure.1 Quantitative evolution of scientific articles.

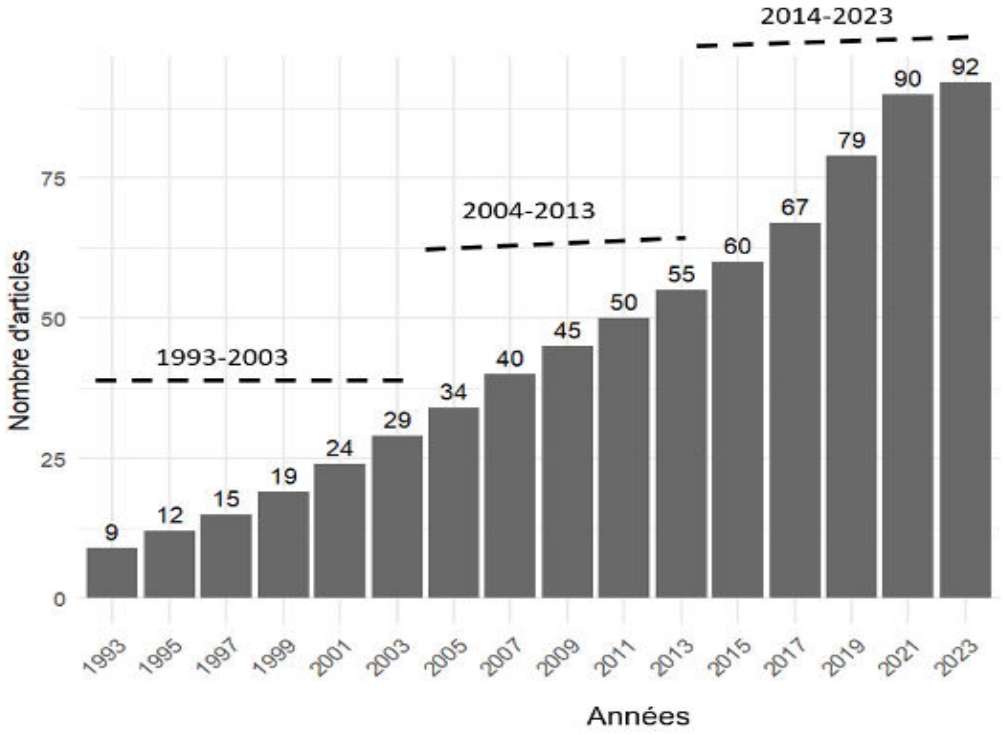
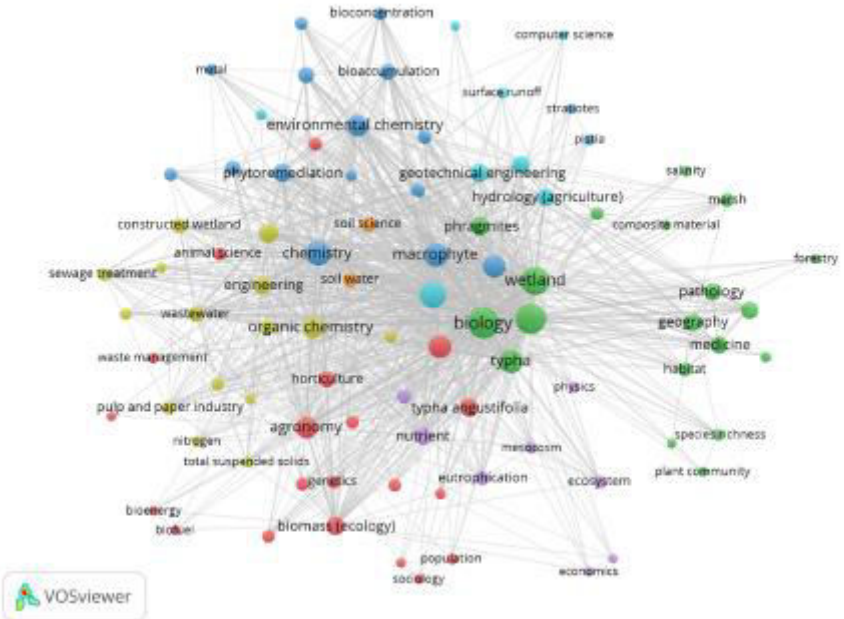


Figure.2 Mapping of scientific disciplines.



Each node represents a **keyword**; the **size of the node** indicates the frequency of keyword occurrence; the **distance between nodes** represents the strength of the relationship (co-occurrence); and the **colors** represent thematic clusters (research fields).

Figure.3 Evolution of disciplinary fields (1993–2023).

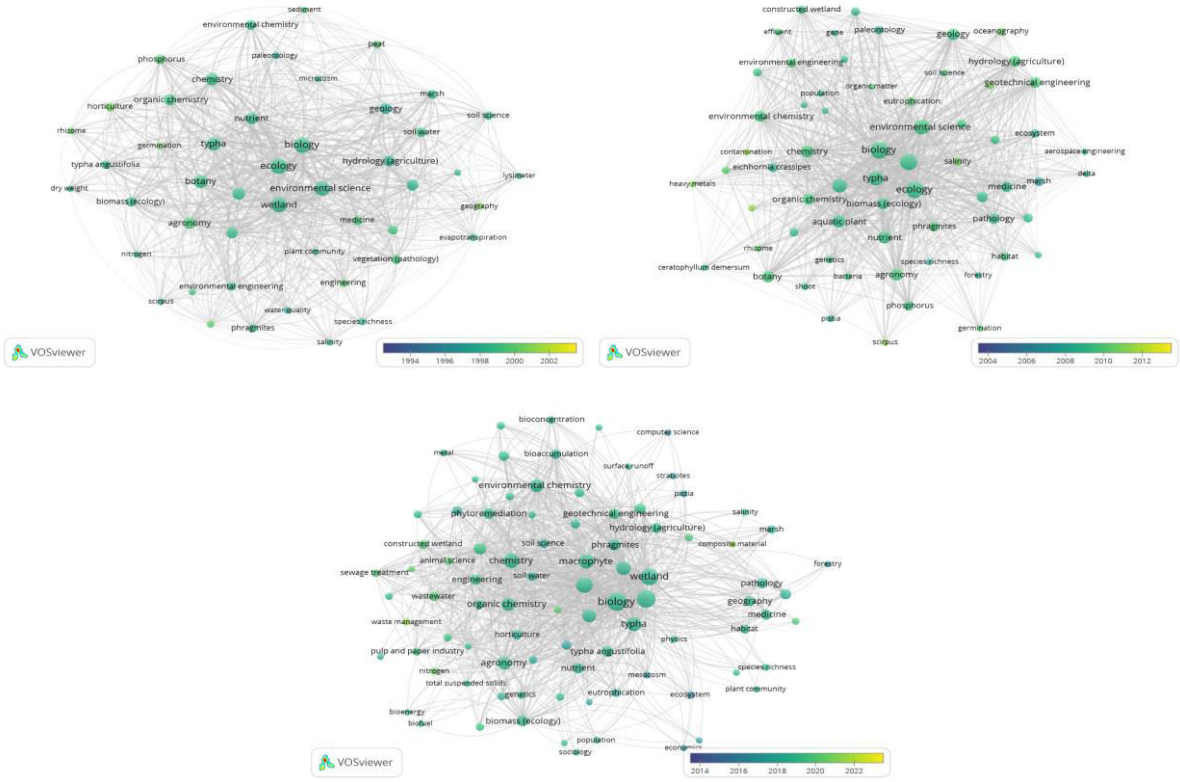


Figure.4 Relationships between institutions.

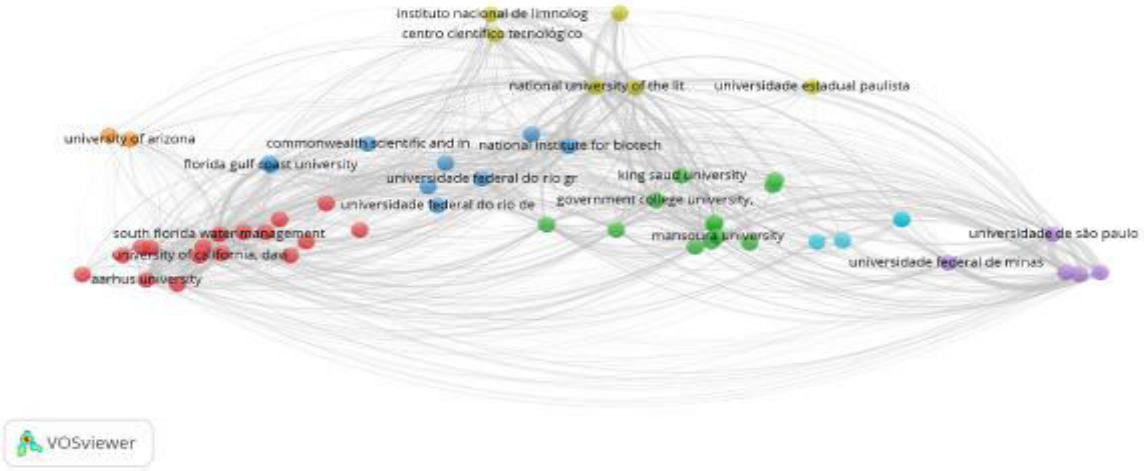


Figure.5 Edaphic factors controlling the proliferation of *Typha domingensis*.

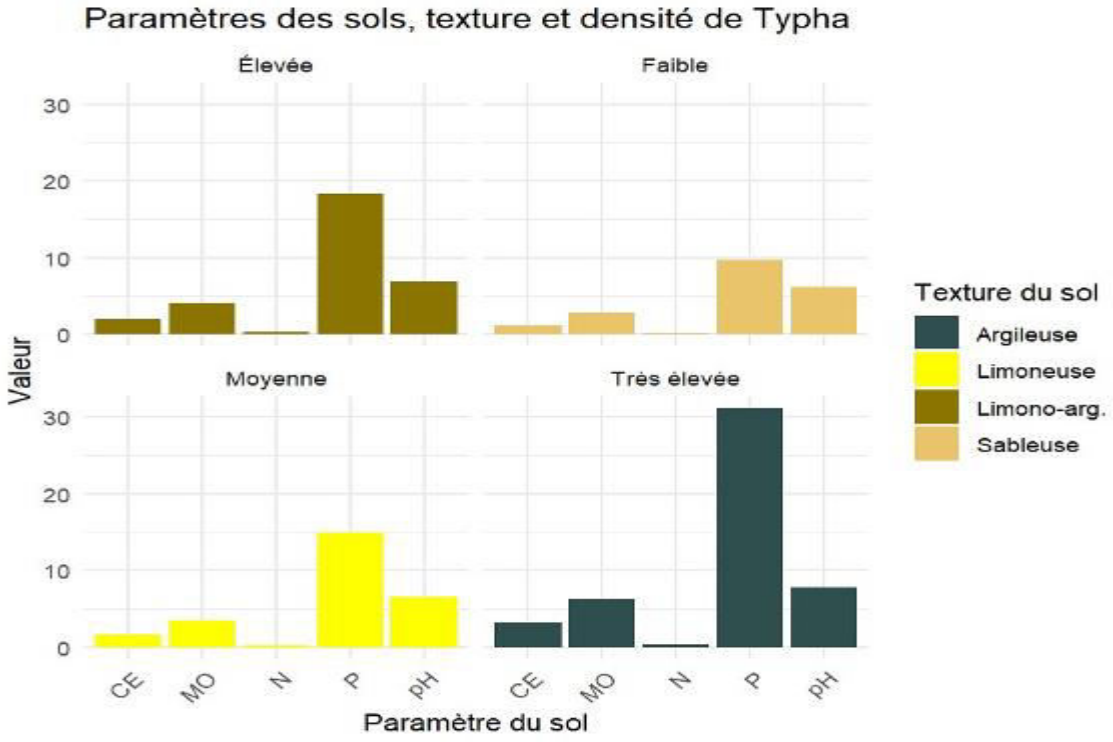
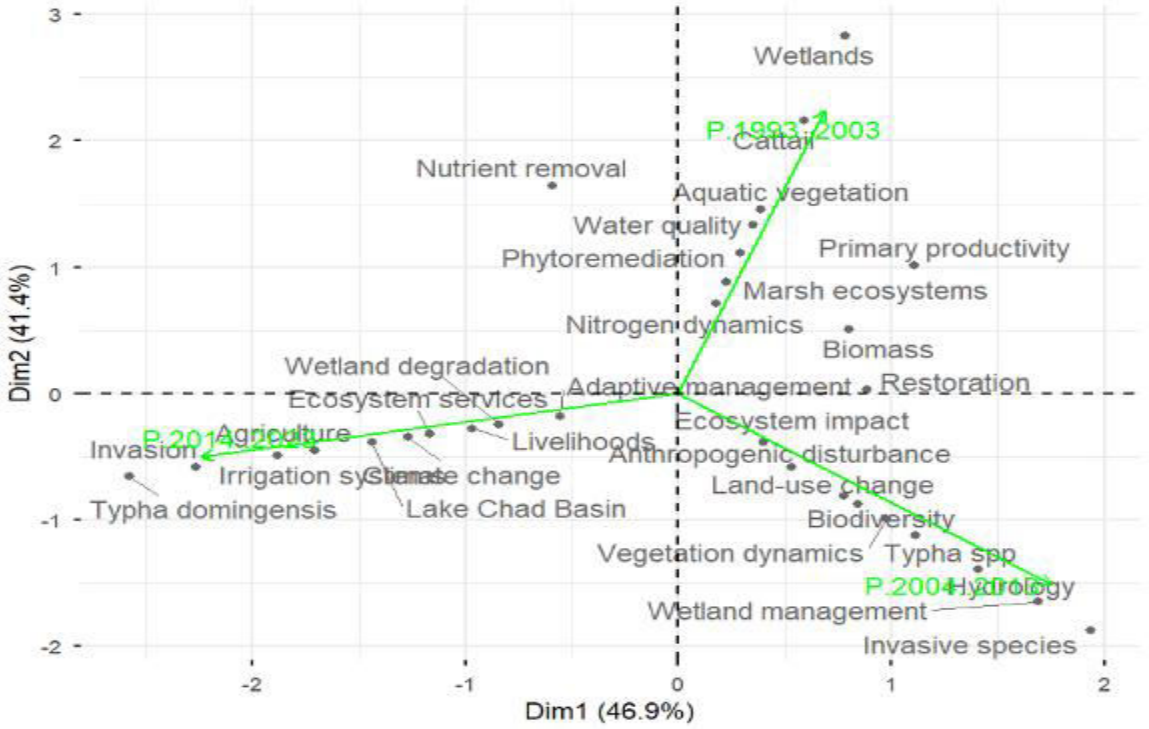


Figure.6 Temporal analysis of keywords.



Constructed Wetlands and Applied Hydrology

The emergence of keywords related to environmental engineering and irrigation systems indicates that *Typha* is increasingly studied for its capacity to treat wastewater and regulate nutrients, reflecting the direct application of scientific knowledge to sustainable management (Brix, 1997).

Socio-economic Impacts and Climate Change Adaptation

Recent publications highlight the influence of ***Typha*** on agriculture, livelihoods, and food security**,** particularly in the Lake Chad Basin**.**

This orientation underscores the need to integrate ecological and hydrological knowledge into development strategies and resilience planning, especially in the face of climate disturbances and biological invasions.

Collaboration Networks and Scientific Structuring

The analysis of institutional relationships indicates that the development of this research field is strongly influenced by international collaborations, dominated by Brazilian, North American, and European research hubs**.**

This structure suggests a methodological and theoretical diffusion from the Global North to the Global South, while also highlighting the gradual emergence of regional and African actors**.** This phenomenon is typical of research on invasive species and wetland management**,** where knowledge and technology transfer plays a crucial role in the adoption of integrated management practices (Simberloff *et al.,* 2013).

In conclusion, the bibliometric analysis conducted confirms the growing importance of *Typha domingensis* Pers. as a scientific research subject in wetlands of southeastern Niger and the broader Sahel region. Scientific production has shown sustained growth, reflecting increasing interest in both the ecological functions and socio-economic impacts of this species.

The disciplinary evolution reveals a transition toward integrated and applied approaches, combining ecology, hydrology, phytoremediation, and environmental engineering**.** Emerging themes highlight the need to reconcile biodiversity conservation, sustainable wetland management, and community resilience in the face of biological invasions and climate change**.**

Finally, the network of international collaborations underscores the importance of knowledge and technology transfer between Northern countries and African research actors**,** while also identifying a need to strengthen locally grounded research in the Sahelian context.

These findings provide essential insights to guide management policies, environmental planning, and future research strategies on *Typha domingensis* and Sahelian wetland ecosystems.

Author Contributions

ASSOUMANE ISSA Adamou: Investigation, formal analysis, writing—original draft. LAOUALI Abdou: Validation, methodology, writing—reviewing. KAOULE Karema Ary Madou:—Formal analysis, writing—review and editing. MAHAMANE Ali: Investigation, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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