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Assessing biodiversity risks in African agriculture for the One Food Risk: A review of research trends through bibliometric analysis

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ABSTRACT

Food systems are central to human well-being and food security, but are also major drivers of biodiversity loss through deforestation, land conversion, monoculture, and intensive agrochemical use. Guided by One Health philosophy and aligned with the One Food Programme, this study assesses biodiversity risks associated with African food systems. A bibliometric and narrative review of nearly 12,000 peer-reviewed studies was conducted to examine research trends, hazards, risks, impacts, and adaptation strategies related to biodiversity and agriculture in Africa. Results show increase on agriculture–biodiversity linkages since 2001, although, African researchers remain underrepresented and geographic coverage is uneven. Research is concentrated on terrestrial systems, while aquatic food systems, including fisheries and aquaculture, receive comparatively limited attention. Biodiversity risks linked to post-production stages of food systems, such as processing and distribution, are poorly studied. The findings further indicate that unsustainable intensification contributes to soil degradation, biodiversity loss, and declining ecosystem services, whereas practices such as agroforestry, intercropping, conservation agriculture, and integrated aquaculture can support resilience and sustainability. The study identifies major research gaps and highlights the need to integrate biodiversity risk indicators into the One Food Risk Tool to support evidence-based policies for sustainable and resilient food systems in Africa.

1. Introduction

The One Health philosophy is grounded in the interconnected pillars of human, environmental, animal, and plant health, meaning that problems affecting one can influence the others [1]. Within this broader framework, the One Food Programme focuses specifically on food systems and their sustainability, resilience, and implications for health and environmental integrity.. Within this framework, biodiversity forms a key component of environmental health because of its essential role in maintaining ecosystem functions, food security, and sustainable food production. As food systems depend heavily on natural ecosystems, the One Food approach supports efforts to address land degradation, biodiversity loss, water stress, pollution, and climate change through resilient and sustainable agricultural practices [1]. In this study, the One Food approach provides a framework for understanding how biodiversity risks emerge across food systems and how these risks affect environmental sustainability, food security, and human well-being. Despite increasing recognition of biodiversity loss as a major sustainability challenge, there is still limited consolidated evidence on how biodiversity risks linked to agriculture have been studied across Africa. Existing studies are often fragmented across disciplines, regions, and food system components, making it difficult to identify dominant research themes, emerging trends, and critical knowledge gaps. This study therefore uses bibliometric and narrative approaches to systematically examine research patterns, biodiversity risks, impacts, and response strategies associated with African food systems.

The global population is projected to reach 9.7 billion by 2050 [2]. Meeting the growing demand for safe, nutritious, and healthy food will require production to increase by >50% above 2012 levels [1,2]. While increasing food production to meet future food needs, it also raises concerns about the sustainability of natural resource use and the growing pressure placed on biodiversity and ecosystem services. Rising evidence shows that this increased demand for natural resources can drive unsustainable use and overexploitation, threatening biodiversity and ecosystem functioning [3,4]. Biodiversity at genetic, species, and ecosystem levels is critical for ecosystem function and resilience,

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including agricultural production systems [5,6]. Anthropogenic activities such as habitat destruction, land degradation, invasive species, and land-use change are major drivers of biodiversity loss and ecosystem alteration [7–9]. In regions such as China, India, and Southeast Asia, nearly two-thirds of mammals are threatened with extinction [10]. These trends highlight the potential consequences of unsustainable development pathways, which are also increasingly relevant to Africa as population growth and food demand continue to rise if conservation is not prioritised [11,12]. In food systems, both direct and indirect drivers of biodiversity loss occur at multiple levels of the value chain including production, processing, distribution, consumption, and disposal [10]. Population growth and shifting dietary preferences will further fuel demand, while biodiversity loss amplifies sustainability challenges in agriculture [12].

Food system activities including habitat loss, species over-exploitation, pollution, climate change, and the introduction of invasive alien species place severe stress on biodiversity [13]. Expansion of agricultural land, especially through forest conversion for croplands and pastures, remains the most significant driver globally [14]. Intensive practices such as monocropping and heavy use of pesticides and fertilizers also contribute to declines in pollinators, soil organisms, and freshwater biodiversity [15]. Livestock, fisheries, and aqua-culture add to the risks through land-use change, overfishing, and pollution [16].

The biodiversity impacts of food systems also carry social, economic, and environmental risks. Loss of biodiversity undermines ecosystem services vital for food security, including soil fertility, pest control, pollination, forage production, and water regulation [17,18,10]. Ecosystem degradation heightens vulnerabilities for indigenous communities, rural populations, and smallholder farmers who rely directly on biodiversity for livelihoods [19]. It also increases the exposure of food production systems to climate shocks and pests, disrupting global food supply chains [20].

To minimize these impacts while ensuring food security, effective mitigation and adaptation strategies are needed. Potential pathways include agroecological approaches, sustainable resource use, landscape-level conservation, and diversified production systems [21]. Policy interventions, market-based incentives, and consumer shifts toward sustainable diets and sourcing can further enhance sustainability [22,23]. Technological innovations such as precision agriculture, alternative proteins, and conservation of genetic resources offer opportunities to simultaneously reduce biodiversity loss and increase productivity [24].

In line with One Health, the One Food Programme was established to embed these principles into food systems by identifying risks to human, animal, and environmental health and using them to guide responses that enhance food safety and system-wide health. Its framework rests on three interconnected pillars of human, animal and plant, and environmental health, highlighting the interdependence of food systems, people, ecosystems, and living organisms. This integrated approach balances improved nutrition and food safety (human health), protection of natural resources and biodiversity (environmental health), and the welfare of animals and plants to achieve sustainability. Sustainability here refers to meeting present needs without compromising future generations, balancing environmental, social, and economic considerations for resilience and equity.

The concepts of hazards, risks, impacts, and adaptation and mitigation are key to assessing biodiversity risks in agriculture [25]. Hazards are potential sources of harm to biodiversity from food system activities or environmental factors, while risk is the likelihood of a harmful event such as population decline or species loss multiplied by its consequences [26]. For example, excessive pesticide use in farming can act as a hazard by threatening pollinator populations, increasing the risk of reduced pollination services and lower crop productivity. Climate change intensifies risks by disrupting growing seasons, increasing extreme weather events, and altering pest and disease patterns, thereby threatening biodiversity. Impacts are the realized consequences of these risks [27]. To address these challenges, adaptation and mitigation strategies are developed and implemented. Adaptation strategies adjust agricultural practices to cope with risks, such as using climate-resilient crops, restoring habitat corridors, or diversifying farming systems [28]. Mitigation strategies aim to reduce underlying drivers of biodiversity loss [29].

A key objective of the One Food Programme is the development of the One Food Risk Tool, designed to integrate biodiversity risks into food system assessments. The One Food Risk Tool is intended to support evidence-based decision-making by identifying and assessing risks affecting environmental, animal, plant, and human health across food systems. Given the complex interactions between biodiversity and food systems, this study applies bibliometric and content analysis to examine how agricultural activities affect biodiversity, the associated risks and impacts, and potential adaptation and mitigation strategies in the African context. It addresses three questions: What key biodiversity risks are associated with agricultural activities? How do these risks vary across Africa’s agricultural systems? Which strategies are most effective in conserving biodiversity and strengthening ecosystem resilience in agricultural landscapes?

2. Materials and methods

2.1. Bibliometric analysis

This study adopted a qualitative approach to review trends, gaps, and emerging research priorities related to biodiversity risks in African agriculture. Two complementary methods were applied. First, a bibliometric analysis of peer-reviewed literature was conducted to identify publication trends, geographic patterns, influential authors, institutions, and thematic developments. Second, a narrative literature review was used to interpret and synthesize the key themes, common findings, and research gaps identified through the bibliometric analysis. Scopus was selected because it provides broad multidisciplinary coverage, standardized citation information, and compatibility with bibliometric software tools [30,31]. However, reliance on a single database and English-language publications may have excluded relevant studies indexed elsewhere or published in other languages, particularly from Francophone and Lusophone African countries.

The search was restricted to peer-reviewed articles, review papers, and conference proceedings in English, with no date limits, to capture long-term trends. Only studies addressing hazards, risks, and impacts of food system activities on biodiversity were included. The review focused on Africa due to its biodiversity hotspots under pressure from agricultural expansion. The search targeted studies on biodiversity hazards, risks, impacts, adaptation, and mitigation in African food systems. Boolean operators (AND/OR), wildcards (*), and quotation marks were applied across titles, abstracts, and keywords (Table S1). The search returned 13,242 publications: 11,892 research articles, 856 reviews, and 494 conference papers. Only research articles were retained for analysis to ensure consistency in the type of evidence assessed and to focus on original empirical research. Review articles and conference papers were excluded because they may contain synthesized findings, preliminary results, or limited methodological detail. Metadata (titles, abstracts, authors, journals, years) were exported from Scopus in CSV format. The bibliometric analysis was conducted using the full set of 11,892 research articles. From this dataset, a smaller subset of studies was later selected for the narrative review through additional screening based on relevance, citation frequency, publication year, and thematic alignment with the five analytical domains.

Spatial distribution of studies was mapped using R v.4.4.33 [32]. Automated text mining extracted country names from titles and abstracts, matched against a predefined list of 54 African countries. Studies covering multiple countries were disaggregated to assign counts per country, and results were visualised in Excel maps. VOSviewer (v.1.2.4) was used for co-authorship and keyword co-occurrence analyses to identify collaboration patterns and major research themes [33,34].

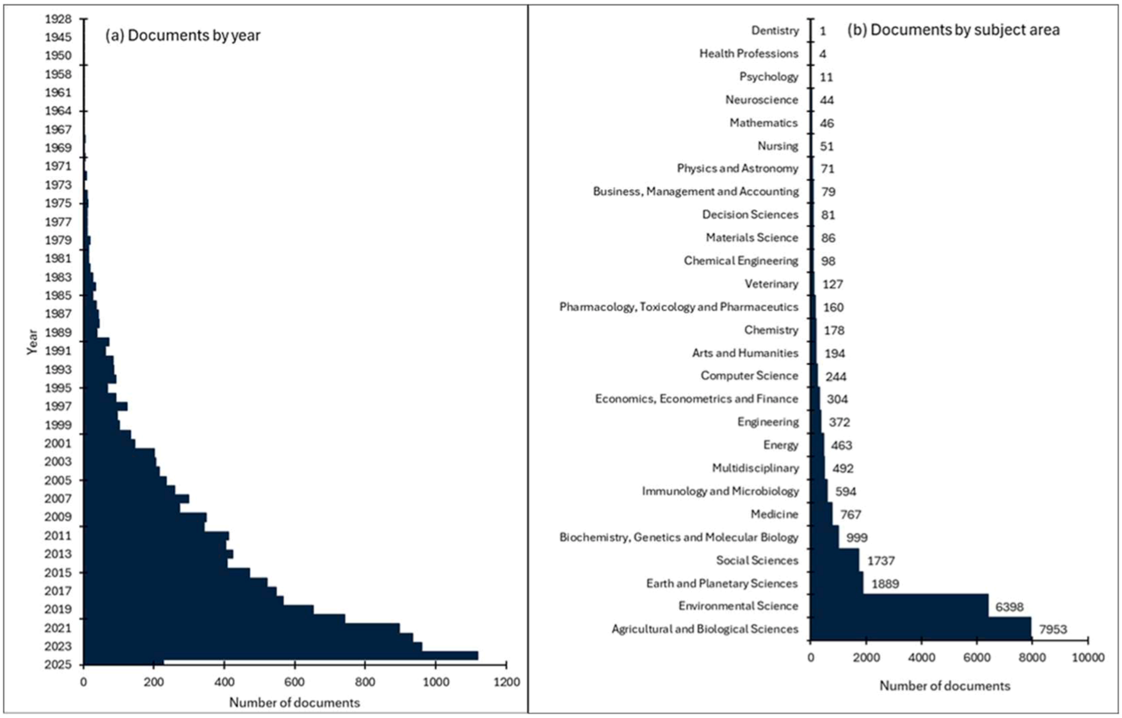

Fig. 1. (a) Annual scientific research publications on key biodiversity risks associated with food system activities in Africa (1928–2025) and (b) top 27 disciplines featured. Database used: Scopus.

Keyword analysis (threshold $\geq$5 occurrences) generated 6771 terms, of which 557 relevant keywords were retained after removing duplicates, combining synonyms, and excluding generic terms. Network maps were then used to identify clusters related to hazards, risks, impacts, adaptation, and mitigation. Broad terms such as biodiversity, agriculture, fisheries) were excluded to improve interpretability. Outputs were further visualised in R using dplyr, ggplot2, and viridis [35]. Total Link Strength (TLS) was used to assess the strength of keyword connections, while average publication year highlighted emerging research themes.

2.2. Narrative literature review

To examine how biodiversity risks are addressed in agricultural research, the literature database was systematically assessed to identify articles for narrative review. The review was guided by the bibliometric analysis, which highlighted prominent keywords across 11,892 publications, grouped into five domains: hazard, risk, impact, adaptation, and mitigation. Articles were screened for relevance to these domains, with priority given to highly cited and recent studies (mainly from the past five years). This ensured focus on evidence showing how biodiversity risks are framed in food systems, while capturing emerging themes, gaps, and trends in African contexts.

The review followed two steps. First, papers were screened by citation frequency, with a cutoff of 100 citations to ensure inclusion of influential work. While this approach may favour older studies with longer citation histories, more recent studies published between 2020 and 2024 were also included to capture emerging developments. Systematic reviews were retained for their rigor and comprehensive synthesis, and older foundational papers were included where relevant. Additional criteria included alignment with the five domains, African focus, and availability in English. Abstracts and full texts were manually screened. Studies were excluded if they lacked a clear focus on biodiversity risks in African food systems, did not address at least one of the five analytical domains, or provided insufficient methodological or contextual information relevant to the review objectives. In total, 209 articles met the criteria, covering themes such as agriculture and biodiversity, land-use change, climate change, risks, impacts, and adaptation. These papers were qualitatively analysed to identify emerging trends, theoretical frameworks, methodological approaches, and regional gaps in biodiversity risk research. Table S2 shows all the articles that were reviewed.

3. Results and discussions

The results are organised into four parts: publication trends, key biodiversity risks and hazards, their impacts on biodiversity, and potential solutions. The analysis highlights major themes, gaps, and emerging issues, with particular focus on adaptation and mitigation strategies to address biodiversity risks from agriculture.

3.1. Temporal and spatial publication trends

Between 2001 and 2025, scholarly output on biodiversity risks in agriculture grew significantly, with 2024 (n = 1120; 8.5%) being the most prolific year (Fig. 1a). This surge reflects rising awareness of the environmental impacts of unsustainable agriculture, particularly biodiversity loss and declining productivity from land degradation [6,36]. Other contributing factors include the expansion of international research collaborations, the role of NGOs in promoting sustainable practices, government and NGO prioritisation of biodiversity conservation, and the need for scientific evidence to inform policy integration [37].

By contrast, the period 1928–1964 recorded the fewest articles, with only one per year (<0.01%). These early studies helped establish the foundation for future research by highlighting links between agricultural practices and biodiversity loss. Over time, evidence showed that human activities such as agriculture could disrupt ecosystems and contribute to biodiversity decline [38]. Although protecting agricultural land became increasingly important, policy implementation remained limited due to financial, institutional, technical, and political constraints [39].

The percentage growth rate shows an average annual increase of

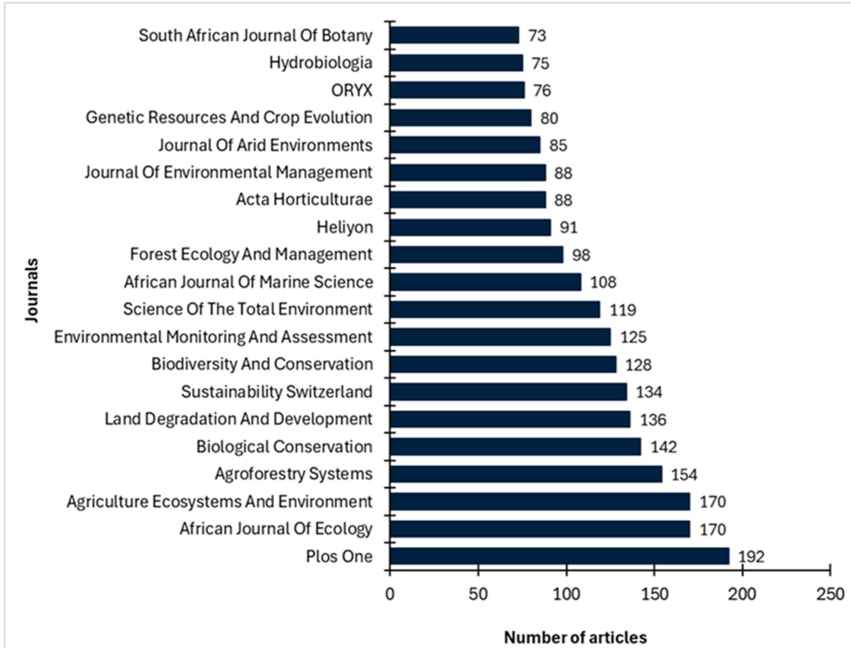

Fig. 2. The top 20 scientific journals on key biodiversity risks associated with agricultural activities in Africa.

31.83% in publications between 1928 and 2025, reflecting rising environmental concerns. Overall, the number of articles on biodiversity risks from agriculture in Africa has risen exponentially (Fig. 1a). Agricultural and Biological Sciences (n = 7953) and Environmental Science (n = 6398) dominate research output, followed by Earth and Planetary Sciences (n = 1889) and Social Sciences (n = 1737). Biochemistry, Genetics and Molecular Biology (n = 999) and Medicine (n = 767) also contribute. In contrast, Dentistry (n = 1), Health Professions (n = 4), and Psychology (n = 11) show minimal engagement (Fig. 1b). These trends highlight a strong focus on environmental and sustainability research, while the lower representation of social sciences and health-related disciplines may reflect the traditional framing of biodiversity loss as primarily an ecological issue rather than a broader socio-economic and public health challenge.

3.1.1. *Most relevant journals*

The bibliometric analysis showed a wide distribution of publications across journals, with key outlets in environmental science, ecology, and sustainability. Among the top 20, *PLOS One* published the most articles (n = 192), followed by *African Journal of Ecology and Agriculture, Ecosystems and Environment* (n = 170 each), reflecting strong emphasis on ecological and agricultural sustainability. Other leading journals include *Agroforestry Systems* (n = 154), *Biological Conservation* (n = 142), and *Land Degradation and Development* (n = 136), highlighting sustained interest in conservation and land management. *Sustainability* Switzerland (n = 134) and *Biodiversity and Conservation* (n = 128) also contributed substantially. Broader interdisciplinary engagement is seen in *Science of the Total Environment* (n = 119), *Environmental Monitoring and Assessment* (n = 125), and *African Journal of Marine Science* (n = 108). Journals with fewer but notable contributions include *South African Journal of Botany* (n = 73), *Hydrobiologia* (n = 75), and *ORYX* (n = 76), which focus on botany, aquatic ecosystems, and biodiversity conservation, respectively (Fig. 2).

3.1.2. *Regional trends and co-authorship analysis in African studies of biodiversity in food systems*

Country-level analysis shows that biodiversity research in food systems is highly uneven across Africa, with South Africa, Ethiopia, and Kenya emerging as leading hubs (Fig. 3). In contrast, many Central and West African countries show far lower output in this English-language review (Fig. 3a & b). This disparity reflects differences in institutional capacity, funding, language barriers, and academic infrastructure. In particular, the dominance of French in parts of Central and West Africa may limit the visibility of research in predominantly English-indexed databases and scientific networks. Density visualisation reinforces this pattern, with bright yellow clusters marking areas of high research intensity. South Africa is the most prolific contributor, followed by Ethiopia, Kenya, and Nigeria, while much of North and Central Africa shows limited activity.

The co-authorship network highlights strong collaborations among scholars in South Africa, Ethiopia, Kenya, and Nigeria, which appear as central nodes with extensive partnerships across the continent. Research active nations show denser linkages, reinforcing their role as key drivers of African scholarship. Temporal analysis from 2000 to 2024 shows an upward trend in collaborations, with new partnerships emerging in recent years, indicated by lighter shades in Figure 3(c).

The co-authorship network, as illustrated in Fig. 4, consisted of 28 distinct clusters, with an average publication year of 2010. Prominent researchers such as Brice Sinsin, Jan Nyssen, Andreas Buerkert, and Mitiku Haile appeared as central nodes in the network, reflecting their extensive collaborative efforts across multiple research domains. These key authors play a significant role in shaping research discourse and fostering interdisciplinary partnerships within this field of biodiversity and food systems.

3.2. *Keywords co-occurrence analysis*

The keyword co-occurrence analysis identified four thematic clusters in biodiversity risk research related to agriculture (Figure 5; Table 1). Central themes include biodiversity loss, land-use change, and climate change, reflecting the focus on the ecological consequences of terrestrial agricultural expansion. Related terms such as deforestation, soil degradation, and habitat fragmentation reinforce the impacts of agricultural growth on ecosystems. The analysis also revealed emerging topics forming peripheral clusters. The interconnectedness of keywords points to a multidisciplinary approach combining conservation science, sustainable agriculture, and environmental policy. These patterns highlight the growing recognition of biodiversity risks in agriculture and the need

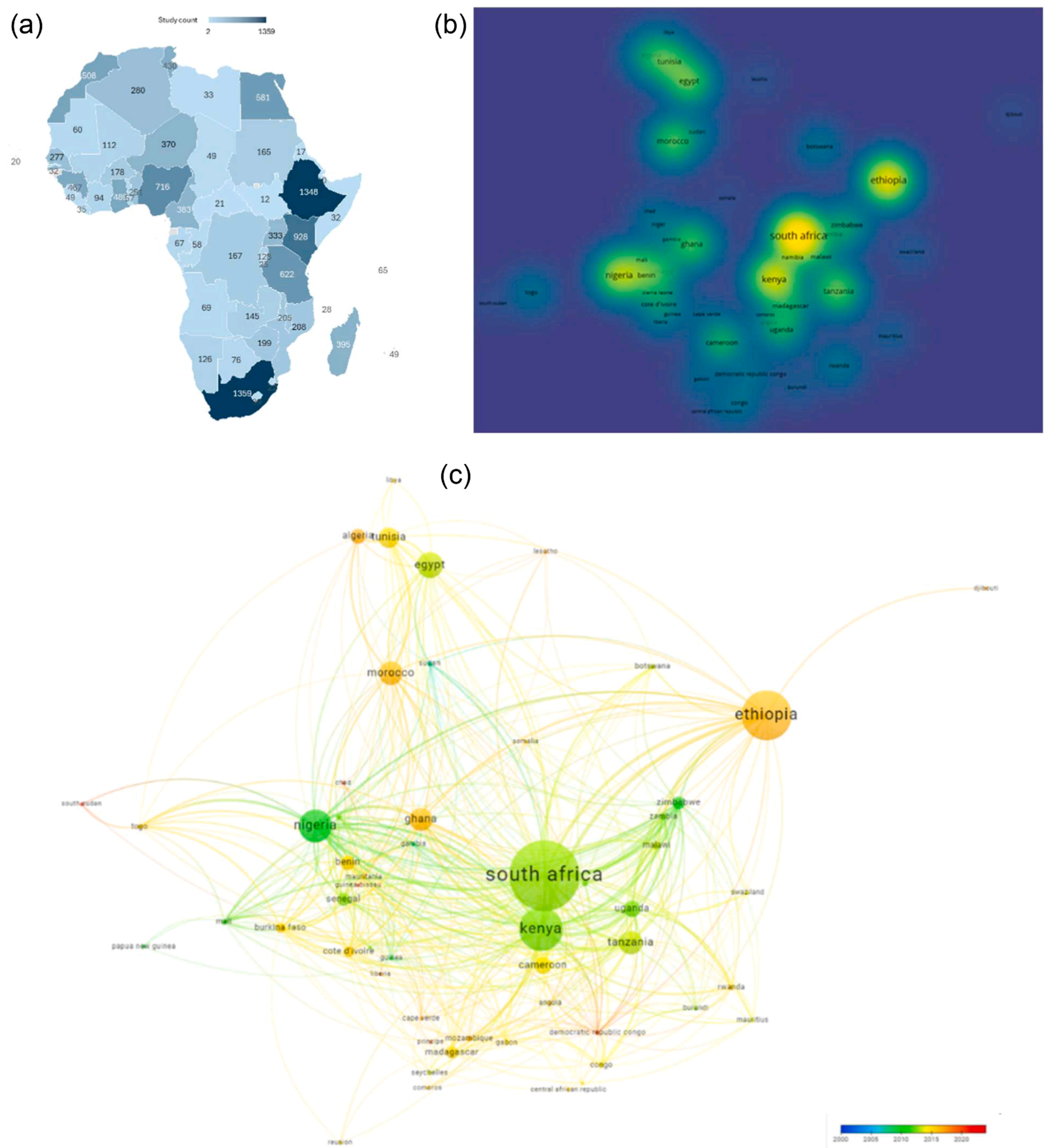

Fig. 3. Geographic distribution of research activity and co-authorship networks in Africa. (a) study counts per country, (b) research density visualisation, and (c) co-authorship network between countries, showing collaboration patterns and their evolution from 2014 to 2018.

for integrated response strategies.

In African literature, keywords linked to aquaculture and fisheries are scarce, suggesting that biodiversity risks in aquatic food production have received limited attention. Weak or absent connections to terms such as marine biodiversity, overfishing, and coastal ecosystems further highlight a research gap on the impacts of aquaculture and fisheries in Africa. This gap is an important finding given the increasing global reliance on both terrestrial and aquatic resources (e.g. [40]). By contrast, extensive research on fisheries, aquaculture, and biodiversity exists in Europe, the Americas, and Asia [41]. These findings demonstrate the need for greater research attention to aquatic food systems within biodiversity risk assessments in Africa.

Beyond aquatic systems, the analysis also revealed several other underexplored areas in biodiversity risk research. Limited attention has been given to biodiversity risks associated with food processing, distribution, consumption, and waste management stages of food systems, despite their growing environmental impacts. Socio-economic dimensions, including gender, livelihoods, indigenous knowledge systems, and public health implications, also remain insufficiently integrated into biodiversity risk assessments. In addition, research is unevenly distributed across Africa, with relatively limited studies from Central and North Africa, highlighting important geographic and institutional gaps.

Based on total link strength (TLS), the main agricultural hazards and risks to biodiversity include ranged from irrigation, forestry or plantations, water pollutants, land-use change, deforestation, fertilizers, pesticides, soil pollutants, to agricultural intensification (Fig. 6a, b). Emerging research increasingly focuses on water and soil pollutants. Irrigation alters hydrological cycles and threaten both aquatic and terrestrial biodiversity, while fertilizers and pesticides introduce chemical pollutants into soil and water ecosystems. Deforestation and land-use change drive habitat loss and fragmentation, and plantations contribute to landscape homogeneity. Although agricultural intensification can enhance productivity and food security, it often promotes

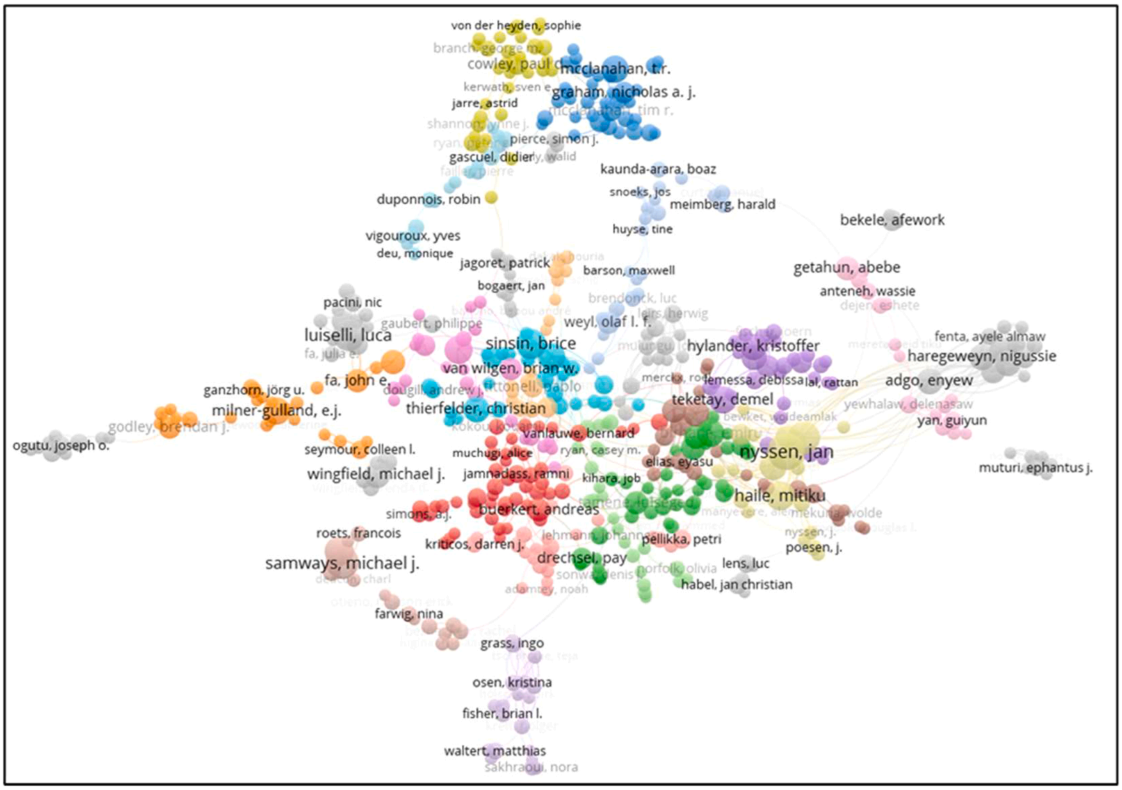

Fig. 4. Co-authorship links in African studies on biodiversity in food systems.

Table 1
Some of the cluster relationship keywords.

Cluster #	Keywords in the cluster
Cluster 1 (red)	Biodiversity, deforestation, habitat fragmentation, intercropping, land degradation, tillage, land use change, management practices, manure, microbial activity, monocultures, overgrazing, overfishing, rangeland expansion, tillage
Cluster 2 (green)	lake pollution, river pollution, salinisation, sedimentation, water contamination, water physicochemical properties, water pollution
Cluster 3 (blue)	Algal bloom, fisheries management, groundwater pollution, heavy metals, industrial wastewater, marine pollution, sewage, soil erosion, soil pollution, soil fertility degradation, water erosion
Cluster 4 (yellow)	agricultural robots, agricultural workers, animal husbandry, climate change, disease carrier, genetic differentiation, invasive species, leaching, tree planting, toxicity, shifting cultivation, weathering

monocultures that reduce biodiversity. Fertilizer and pesticide runoff pose major threats to aquatic systems [42]. Soil erosion reduces land productivity and degrades downstream water bodies [43]. Water supply challenges, including depletion and contamination, are now global concerns. Runoff contributes to sedimentation and pollutant transfer, while salinity reduces soil fertility [44]. Climate change compounds these risks by altering rainfall patterns, water availability, and land stability.

Frequently reported impacts include declines in water quality, species richness, species diversity, ecosystem services, food security, soil fertility, soil microbiology, and soil quality (Fig. 6c). Water quality declines through sedimentation, nutrient loading, and chemical pollution [45]. Reduced species richness and diversity reflect biodiversity loss caused by habitat change and chemical exposure [46]. Deterioration of ecosystem services threaten food security, while declines in soil fertility, microbiology, and quality jeopardize both agricultural productivity and ecological functioning [47].

Adaptation strategies include agroforestry, water management, sustainable agriculture, agroecology, bioremediation, and pest control (Fig. 6d). Agroforestry, the most emphasized strategy, integrates trees into farming systems to improve biodiversity and resilience [48]. Sustainable agriculture and agroecology support biodiversity-friendly practices, while improved water management reduces environmental stress (Geoffroy [49]). Bioremediation, an emerging theme, employs natural processes to detoxify soils and waters contaminated with pesticides and heavy metals, and integrated pest management reduces reliance on chemicals.

Mitigation measures include environmental monitoring, environmental protection, conservation, remote sensing, and fisheries management (Fig. 6e). Environmental monitoring, the most frequently noted and emerging theme, supports evidence-based decision-making. Conservation initiatives aim to safeguard habitats and species, while policies on environmental protection regulate harmful practices. Remote sensing enables large-scale monitoring and assessment, and fisheries management is critical to maintaining aquatic biodiversity.

3.3. Hazards of food systems activities to biodiversity

Evidence shows that agricultural practices can generate both negative and positive impacts on biodiversity and the environment. Policies aimed at achieving agricultural productivity and environmental sustainability often involve trade-offs. For example, intensive farming can boost yields but cause habitat loss, soil degradation, and pollution, undermining ecological resilience. Tensions may also arise between local communities dependent on natural resources and conservation agencies implementing biodiversity protection measures. Policies therefore need to strengthen practices with positive biodiversity co-benefits while minimizing harmful impacts. Biodiversity degrading food system practices remain the major concern, contributing to habitat loss, pollution, and species decline.

The keyword network visualization (Fig. 7a) shows forestry linked to deforestation, agroforestry, land-use change, carbon, soils, crop

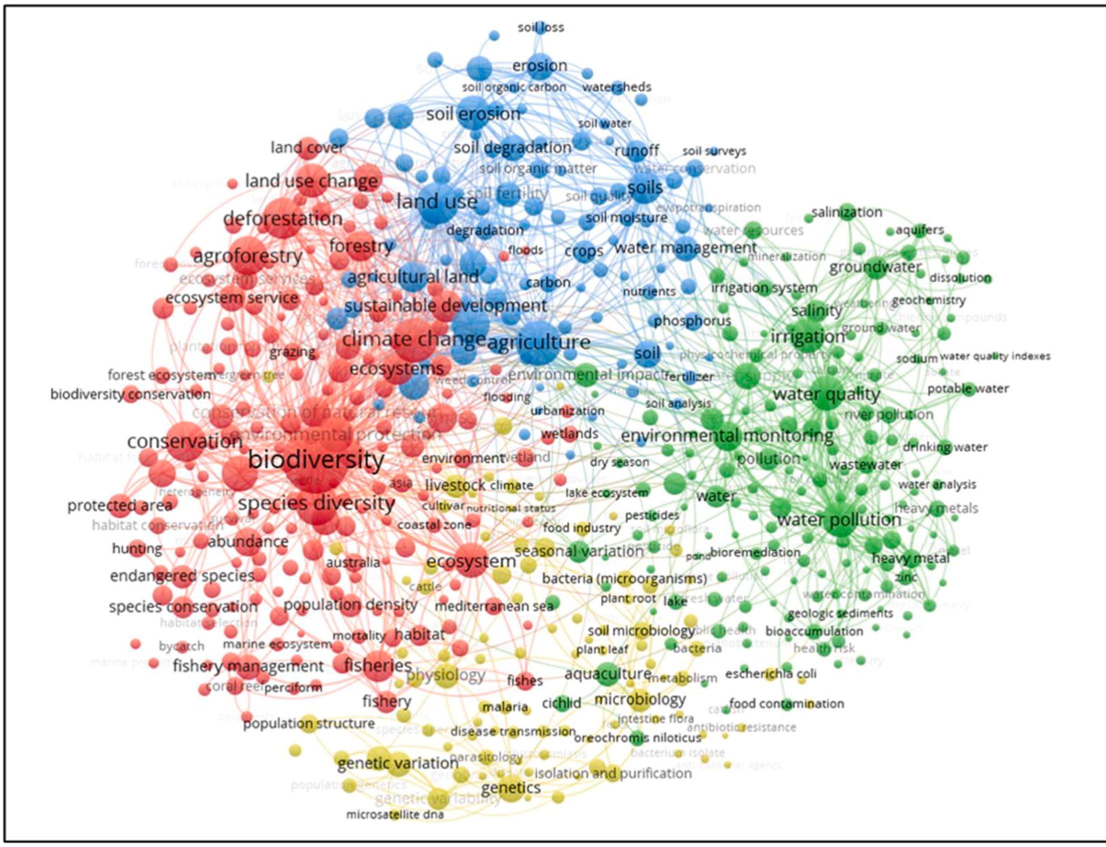

Fig. 5. Visualization of keyword co-occurrence analysis highlighting the relationships between key terms in research on biodiversity risks associated with food systems.

cultivation, climate change, biodiversity, species richness, species diversity, ecosystem services, and land cover. Most studies associate forestry and agriculture with negative biodiversity impacts, particularly through monocultures and unsustainable land-use practices [50]. However, practices such as agroforestry can improve biodiversity outcomes [51]. Land-use change associated with forestry, including deforestation and overgrazing, often replaces diverse vegetation with monocultures, contributing to soil erosion, habitat loss, and biodiversity decline. Rural household activities such as farming, timber harvesting, and firewood collection may further influence these dynamics, particularly where soil degradation, climate pressures, or market incentives encourage agricultural expansion.

Africa's rapid urbanization and population growth have intensified competition for land, leading to widespread forest-to-agriculture conversion with severe biodiversity consequences [52]. Land-use decisions may also be influenced by limited conservation incentives [53] and governance challenges such as policy implementation constraints, stakeholder exclusion, and limited gender integration [54,55]. Reforestation by farmers remains limited without state support [56]. In many cases, forest conservation is treated as a public responsibility requiring government investment, whereas agriculture is primarily managed at the private level.

Links to carbon and climate change show how deforestation disrupts carbon cycles by reducing natural sinks [57]. Agriculture contributes about ±12% of global GHG emissions through deforestation, crop cultivation, and livestock production [58]. Overgrazing accelerates desertification and biodiversity loss [22], while climate variability reduces cereal yields by 5–16% [59] and may threaten 17–35% of species with extinction in the coming century [60].

Positive pathways also exist. Agroforestry improves soil health, carbon sequestration, biodiversity, and livelihoods [61,51]. Figure 7(b) and 7(d) link land-use change to biodiversity loss, climate change, soil degradation, and declining ecosystem services. Habitat fragmentation reduces suitable habitats, genetic diversity, and species abundance [62]. With over 77% of Earth's land already altered, fragmentation increases extinction risks [62].

Agriculture also facilitates invasive and alien species introductions, altering soil, vegetation, and fire regimes [63,64]. Exotic crops, livestock, and fish can outcompete native species, triggering difficult-to-reverse ecosystem changes [65–67]. Figure 7(c) links irrigation to water pollutantion, wastewater, and groundwater challenges. Poor irrigation practices reduce water quality and disrupt wetlands and rivers [68,69]. Intensive irrigation of crops like sugarcane, tea, and avocado has depleted water sources in Eastern and Southern Africa, creating conflicts with urban needs [70] Agricultural runoff carrying fertilizers, pesticides, and pathogens further degrades aquatic ecosystems and drinking water supplies. In South Africa, nutrient pollution has contributed to eutrophication of inland waters, affecting fisheries and local livelihoods [71,72].

Balancing food production and biodiversity conservation remains critical for long-term ecological stability. Yet research often treats agricultural productivity and biodiversity goals in isolation, limiting insights into how land-use strategies can reconcile competing needs. Closing this gap is essential for integrated approaches that secure food systems without undermining biodiversity.

3.4. Risks to biodiversity associated with food system activities

Agriculture is major driver of biodiversity loss through habitat destruction, pollution, and resource exploitation. Risks increase when biodiversity is exposed to stressors such as runoff, drought, soil erosion, and water pollution [73,74]. These pressures also intensify flooding in

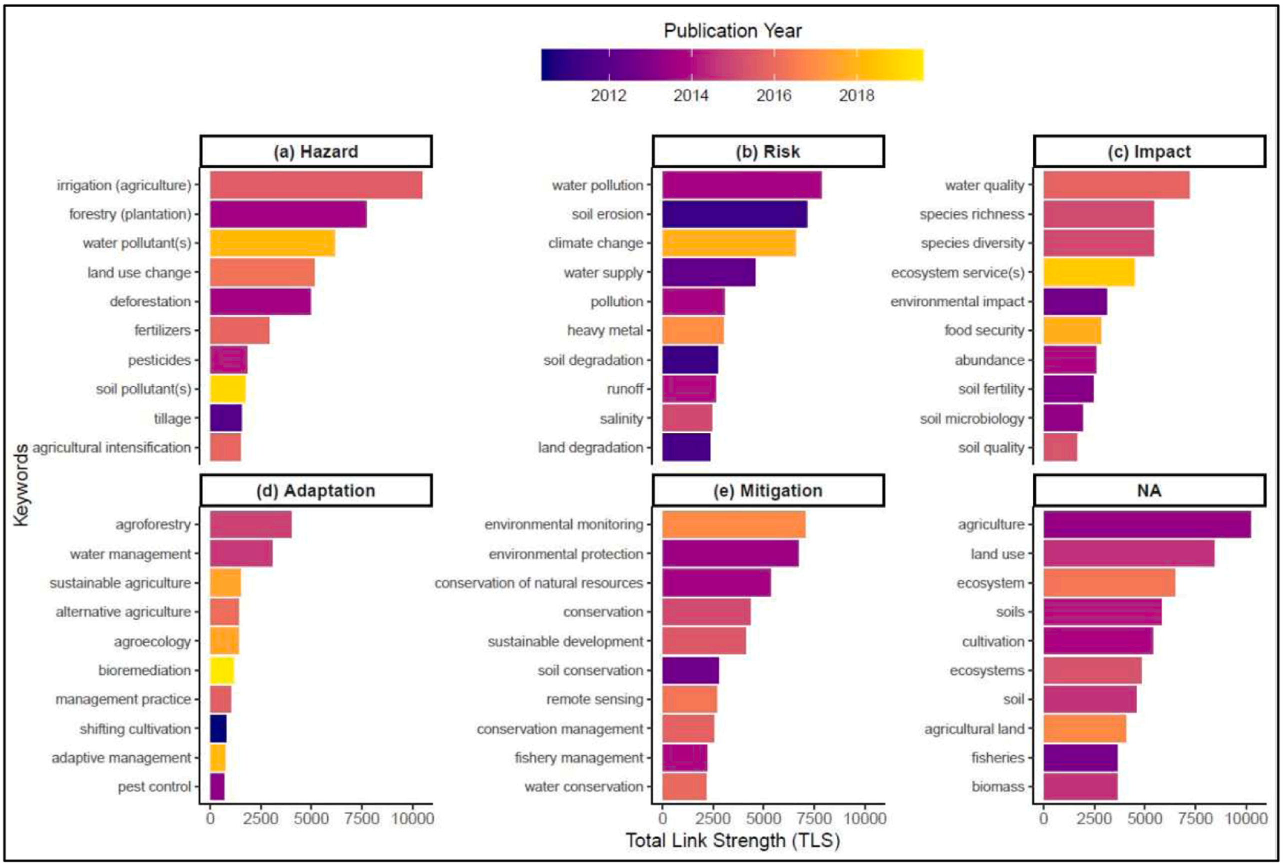

Fig. 6. Top 10 keywords per each category ranked by Total Link Strength (TLS) and coloured by publication year to indicate emerging keywords.

areas experiencing agricultural expansion and deforestation [74]. Sustainable land management and climate resilience are therefore essential. Runoff in smallholder systems is particularly severe, driving soil loss, water pollution, and declining productivity [75].

Figure 8(a) links runoff to agriculture, soil erosion, land use, water supply, water quality, and conservation practices. Risks are highest in smallholder systems with limited erosion control and water-retention infrastructure [75]. Between 1981 and 2016, Africa experienced an average annual runoff increase of 0.3%, mainly driven by land-cover change and climate variability [74]. Forest and grassland conversion in countries such as Guinea and Madagascar increased runoff, accelerating soil erosion and biodiversity loss. Soil compaction from overgrazing further worsens runoff and gully formation [76].

Extreme weather amplifies runoff impacts, causing erosion, flooding, land loss, and water contamination. In southern Africa, drought has been linked to severe soil erosion [77]. Floods between 2018 and 2021 destroyed croplands in the Limpopo Basin, while severe flooding across West and Central Africa in 2024 displaced millions and caused widespread destruction [78]. Climate change is increasing the frequency and intensity of such events [79,80].

Figure 8(b) links soil erosion to land degradation, deforestation, overgrazing, tillage, and climate change. Erosion threatens biodiversity, agricultural productivity, and livelihoods [81]. Unsustainable practices remain major drivers [5], and two-thirds of Africa's productive land is estimated to be degraded. In South Africa, 70% of land is affected [82], while 35% of land in Ghana is vulnerable to desertification [83]. Soil loss also carries major economic costs, including reduced yields and GDP losses [25,84].

Figure 8(c) links water pollution to ecosystems, fisheries, aquaculture, irrigation, heavy metals, and bioaccumulation. Agricultural runoff introduces fertilizers and pesticides into water systems, while industrial discharge, mining and poor sanitation compound risks [85]. . Polluted water promotes toxin accumulation in aquatic species, threatening biodiversity and human health. Only 31% of Sub-Saharan Africa's population had access to safe drinking water in 2022, and untreated wastewater remains a major pollution source [86]. Sub-Saharan Africa is projected to become a global hotspot of surface water pollution [87], with contaminants including pesticides, pharmaceuticals, microplastics, and endocrine disruptors [88].

Figure 8(d) links water supply to biodiversity, conservation, irrigation, ground-water, and climate change. Agricultural expansion reduces water retention and quality through deforestation, wetland loss, and riparian degradation. In the Sahel, agriculture-driven land conversion has contributed to Lake Chad's drying, severely affecting biodiversity and livelihoods. Poor land management increases runoff and siltation, reducing reservoir storage. Agricultural inputs further threaten water quality, promoting algal blooms and fish kills, as seen in East Africa's Mara River. Irrigation amplifies risks by overextracting rivers and lakes, while climate change increases drought and flood frequency, worsening pressures on water supply and biodiversity. Fig. 8.

3.5. Impacts of food system activities on biodiversity in Africa

Biodiversity in African food systems, including terrestrial, soil, wetland, and aquatic ecosystems, is under increasing pressure from the intensification and expansion of agriculture. Below we synthesize the direct and cascading impacts of food system activities on biodiversity, drawing on keyword co-occurrence analyses (Fig. 9) and evidence from the reviewed literature.

3.6. Terrestrial biodiversity loss from land-use change and habitat fragmentation

Land-use change, habitat fragmentation, pollution, overhunting, and

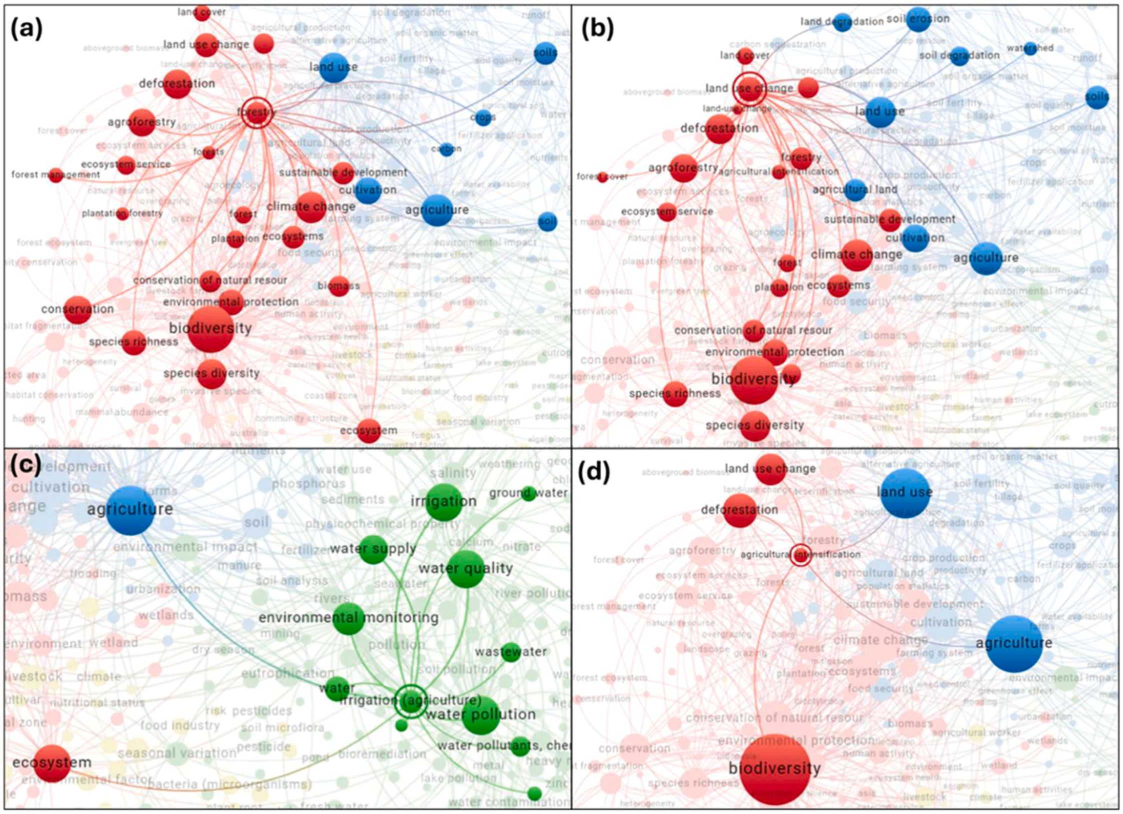

Fig. 7. Keyword co-occurrence network map for hazards: (a) forestry, (b) land-use change, (c) irrigation agriculture, and (d) agricultural intensification. Nodes represent keywords, with larger nodes indicating higher frequency. Lines show keyword co-occurrence, while different colours denote clusters (same colour = same cluster).

invasive species threaten 25% of mammal species, 13% of bird species, and >21,000 plant and animal species with extinction [13,14,12]. Agricultural expansion, particularly deforestation and land conversion, reduces habitat availability and species richness. Keyword networks link species richness to habitat fragmentation, land use change, and agricultural land (Fig. 9a, b), highlighting agriculture's role in biodiversity decline.

In West Africa, cocoa farming contributes significantly to deforestation in Côte d'Ivoire and Ghana [89]. Peri-urban agriculture also caused substantial vegetation loss in Zimbabwe between 1990 and 2020 [57]. Monoculture plantations further reduce habitat complexity and native biodiversity. In South Africa, exotic tree plantations reduced native plant diversity in fragmented grasslands [90], while cocoa expansion in Côte d'Ivoire reduced plant diversity and species richness [91].

3.7. Pollinator biodiversity decline in food systems

Pollinator decline also emerged as an important concern. Fig. 5 links species diversity to agricultural land, climate change, and ecosystem services, reflecting potential trade-offs between productivity and biodiversity. Agricultural intensification and agrochemical use reduce pollinator populations [92–94]. For example, in South African mango orchards, pollination efficiency declined with increasing distance from natural habitats [95]. By contrast, agroforestry systems supported higher bird diversity than monoculture tea plantations in Tanzania [96].

3.8. Soil biodiversity and microbial community disruption from food system activities

Agriculture also affects belowground biodiversity and ecosystem functioning. Figure 9(d) links microbiology to soil agriculture and microbial communities. Intensive tillage, monocultures, and agrochemicals reduce soil organic carbon, nutrient cycling, and microbial diversity. In Ethiopia, eucalyptus plantations acidified soils and reduced organic matter compared to indigenous forests [97]. Cocoa plantations in Côte d'Ivoire decreased soil nitrogen and cation exchange capacity [91]. Soil biodiversity declines were further observed in teak, rubber, and intensively cultivated systems [98,99].

3.9. Aquatic biodiversity decline: pollution and eutrophication due to food system activities

Although aquatic systems remain underrepresented in the literature, findings show that agriculture strongly affects aquatic biodiversity. Figure 9(b) links water quality to eutrophication, pollution, and irrigation. Fertilizer and pesticide runoff contribute to eutrophication, algal blooms, and biodiversity decline in major water bodies [100,101]. In Lake Victoria, links water quality to eutrophication, pollution, and irrigation. Fertilizer and pesticide runoff contribute to eutrophication, algal blooms, and biodiversity decline in major water bodies [102]. Similar impacts were reported in Ethiopia's Lake Hawassa and Awash River, where pollution reduced fish abundance and diversity [103,104]. rrigation infrastructure in Lake Tana also fragmented fish habitats and disrupted spawning [69].

4. Implications for the One Food Risk tool

Biodiversity supports resilient food systems through ecosystem services such as pollination, pest control, nutrient cycling, and soil health. Its decline increases vulnerability to pests, diseases, and climate shocks, and threatening food security, nutrition, and public health. The findings highlight the critical relationship between biodiversity and agricultural systems. Although resilience, food security, and nutrition were not

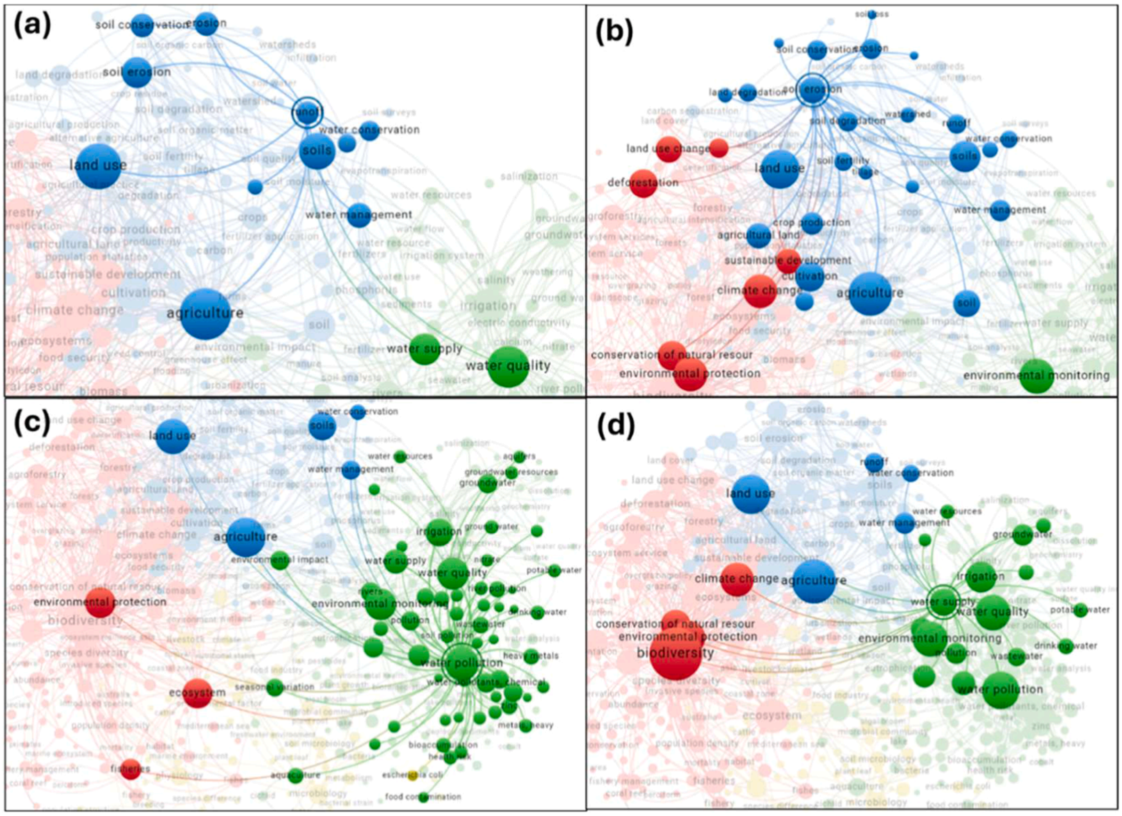

Fig. 8. Keyword co-occurrence network maps for risks: (a) runoff, (b) erosion, (c) water pollution, and (d) water supply. Nodes represent keywords, with larger nodes indicating higher frequency. Lines show keyword co-occurrence. Different colours denote clusters, with the same colour indicating the same cluster.

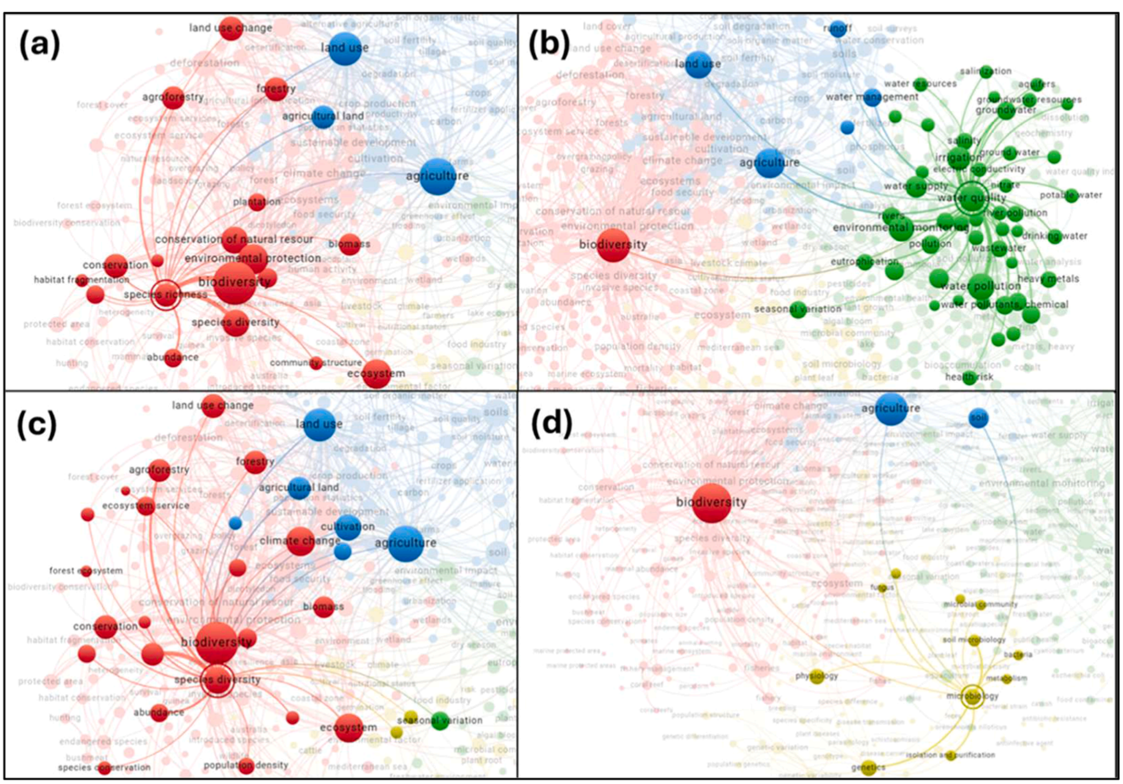

Fig. 9. Keyword co-occurrence network maps for impacts of food system activities on biodiversity: (a) species richness, (b) water quality, (c) species diversity, and (d) microbiology. Nodes represent keywords, with larger nodes indicating higher frequency. Lines between nodes show keyword co-occurrence. Different colours denote clusters, with the same colour indicating the same cluster.

explicit search terms, the results show biodiversity loss as a major driver of ecosystem degradation with broader food system implications. Key hazards and risks identified in African-focused studies include land-use change, monoculture farming, irrigation, pollution, and climate change (Fig. 6), all of which reduce biodiversity and impair ecosystem services. Soil microbiome degradation also emerged as a recurring issue, showing how intensive agriculture and pollution reduce microbial diversity. While inorganic fertilizers may restore degraded systems in the short-term, overreliance can undermines the long-term ecosystem sustainability [105,106]. These findings support integrating biodiversity indicators into the One Food Risk Tool to strengthen environmental, animal, and human health assessments in food systems.

The review also highlights the effects of environmental pollutants on biodiversity and food systems. Heavy metals, agricultural runoff, and microplastics disrupt terrestrial and aquatic ecosystems, reduce species diversity, and promote toxin bioaccumulation. Climate change further intensifies these risks through warming waters, ocean acidification, and extreme weather events that disrupt fisheries and aquatic ecosystems [107]. Integrating pollution and climate-related biodiversity indicators into the One Food Risk Tool would improve its ability to assess long-term risks across the biodiversity–climate–food nexus. The findings further emphasize the need for cross-disciplinary data integration and stronger policy action. Aligning biodiversity data with food production, animal health, and public health metrics would strengthen early warning systems and support sustainable agricultural decision-making. Embedding biodiversity risk assessments into governance frameworks is essential because biodiversity underpins ecosystem services and long-term food security [10,108].

5. Conclusions

The One Health philosophy emphasises the interconnectedness of human, environmental, and animal/plant health, advocating integrated decision-making across these domains. The One Food Programme operationalises this by incorporating hazard identification, risk assessment, and mitigation strategies into food systems to safeguard human, animal/plant, and environmental health. While food systems are essential for global food security, they also pose significant risks to biodiversity through habitat destruction, soil degradation, pollution, and climate change. Practices such as deforestation, monocultures, chemical overuse, and intensive irrigation accelerate biodiversity loss. Balancing productivity with conservation is therefore crucial to sustain ecosystem services. Despite increasing recognition of biodiversity's role in agriculture, knowledge gaps remain on biodiversity hazards, risks, impacts, and adaptation strategies in food systems. This study addresses those gaps in African food systems through bibliometric and narrative analysis.

The review shows growing scholarly focus on agriculture–biodiversity interactions since 2001, though African researchers remain underrepresented. Results also highlight shared challenges, divergent perspectives, and emerging themes across regions. Unsustainable agricultural practices cause habitat degradation, species loss, and reduced ecosystem services. Conversely, practices such as agroforestry, intercropping, conservation agriculture, climate-smart crops, marine protected areas, and integrated aquaculture–agriculture systems enhance biodiversity and food system sustainability. Significant gaps remain. Keywords related to aquaculture and fisheries are scarce, suggesting limited attention to aquatic food systems in African research. Weak links to terms such as marine biodiversity, overfishing, and coastal ecosystems reinforce this gap, despite growing global reliance on aquatic resources. Similarly, little research addresses other stages of the food value chain, such as processing and distribution, even though they were included in the search. This highlights the need for broader integration of aquatic systems and value-chain risks into biodiversity assessments.

Based on the key results highlighted above, the following policy recommendations emerge in alignment with biodiversity in food systems:

- Promote agroecological practices such as crop rotation, integrated aquaculture–agriculture systems, integrated multitrophic aquaculture, and community-based resource management to reduce biodiversity risks.
- Develop policies with incentives, including performance-based payments or biodiversity credits, to discourage unsustainable land use and mitigate soil erosion and pollution.
- Limit harmful agrochemicals, especially pesticides and fertilizers, to protect ecosystems, water quality, and public health.
- Invest in agricultural education, community engagement, and regional collaboration to promote sustainable practices and address cross-border biodiversity risks.
- Expand research and innovation on biodiversity risks in aquatic food systems in Africa, including aquaculture and fisheries, to strengthen resilience and share best practices.

Although research on biodiversity risks in African agriculture has expanded significantly, important knowledge gaps remain. Aquatic food systems, including fisheries and aquaculture, continue to receive limited attention despite their importance for food security and livelihoods. Other underrepresented areas include biodiversity risks across post-production stages of food systems, socio-economic and public health dimensions, indigenous knowledge systems, and interdisciplinary approaches integrating environmental, agricultural, and health sciences. Addressing these gaps will be essential for developing more comprehensive and inclusive biodiversity risk assessments and policies in Africa.

CRediT authorship contribution statement

Malebajoa Anicia Maoela: Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **Felix Vusumuzi Skhosana:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Linda Luvuno:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Herbert Ntuli:** Writing – review & editing, Writing – original draft, Methodology. **Shingirirai Savious Mutanga:** Writing – review & editing, Supervision, Resources, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.sftr.2026.101974.

Data availability

The data presented in this study are available upon reasonable request.

References

[1] S.N. Garcia, B.I. Osburn, M.T. Jay-Russell, One health for Food safety, Food Security, and Sustainable Food production, Front. Sustain. Food Syst. 4 (January) (2020) 1, https://doi.org/10.3389/fsufs.2020.00001.
[2] R. Lal, Feeding 11 billion on 0.5 billion hectare of area under cereal crops, Food Energy Secur. 5 (4) (2016) 239–251, https://doi.org/10.1002/fes3.99.
[3] W. Steffen, P.J. Crutzen, J.R. McNeill, The Anthropocene: are humans now overwhelming the great forces of nature, AMBIO: A J. Human Environ. 36 (8)

(2007) 614–621, https://doi.org/10.1579/0044-7447(2007), 36%255B614: TAAHNO%255D2.0.CO;2.

[4] P.M. Vitousek, H.A. Mooney, J. Lubchenco, J.M. Melillo, Human domination of Earth's ecosystems, in: J.M. Marzluff, E. Shulenberger, W. Endlicher (Eds.), Urban Ecology, Springer, Boston, MA, 2008. https://doi.org/10.1007/978-0-387-73412-5_1.

[5] FAO, Sustainable Fishing Practices in Mauritius, Food and Agriculture Organization, 2019. https://www.fao.org/fishery/en/facp/mus. accessed February 8, 2025.

[6] Millenium Ecosystem Assessment, Ecosystems and Human Well-Being: Biodiversity Synthesis, World Resources Institute, Washington DC, (2005). https://www.millenniumassessment.org. accessed February 20, 2025.

[7] J.C Habel, M. Teucher, R.K. Mulwa, W. Haber, H. Eggermont, L. Lens, Nature conservation at the edge, Biodivers. Conserv. 25 (4) (2016) 791–799, https://doi.org/10.1007/s10531-016-1073-2.

[8] F. Isbell, D. Tilman, S. Polasky, M. Loreau, The biodiversity-dependent ecosystem service debt, Ecol. Lett. 18 (2) (2015) 119–134, https://doi.org/10.1111/ele.12393.

[9] B.M Watuma, S. Kipkoech, D.K Melly, et al., An annotated checklist of the vascular plants of Taita Hills, Eastern Arc Mountain, PhytoKeys 191 (March) (2022) 1–158, https://doi.org/10.3897/phytokeys.191.73714.

[10] IPBES, Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Version 1. Zenodo. (2019). https://doi.org/10.5281/ZENODO.3831673. accessed February 15, 2025.

[11] J.K. McKee, P.W. Sciulli, C.D. Fooce, T.A. Waite, Forecasting global biodiversity threats associated with Human population growth, Biol. Conserv. 115 (1) (2004) 161–164, https://doi.org/10.1016/S0006-3207(03)00099-5.

[12] D. Tilman, M. Clark, D.R. Williams, K. Kimmel, S. Polasky, C. Packer, Future threats to biodiversity and pathways to their prevention, Nature 546 (7656) (2017) 73–81, https://doi.org/10.1038/nature22900.

[13] S.L. Maxwell, R.A. Fuller, T.M. Brooks, J.E.M. Watson, Biodiversity: the ravages of guns, nets and bulldozers, Nature 536 (7615) (2016) 143–145, https://doi.org/10.1038/536143a.

[14] T. Newbold, L.N. Hudson, S.L.L. Hill, et al., Global effects of land use on local terrestrial biodiversity, Nature 520 (7545) (2015) 45–50, https://doi.org/10.1038/nature14324.

[15] N. Dudley, S. Alexander, Agriculture and biodiversity: a review, Biodiversity 18 (2–3) (2017) 45–49, https://doi.org/10.1080/14888386.2017.1351892.

[16] R.S. Cottrell, J.L. Blanchard, B.S. Halpern, M. Metian, H.E. Froehlich, Global adoption of novel aquaculture feeds could substantially reduce forage fish demand by 2030, Nat. Food 1 (5) (2020) 301–308, https://doi.org/10.1038/s43016-020-0078-x.

[17] M. Boval, R.M. Dixon, The importance of grasslands for animal production and other functions: a review on management and methodological progress in the tropics, Animal 6 (5) (2012) 748–762, https://doi.org/10.1017/S1751731112000304.

[18] C. Carbutt, D.I. Thompson, Mountain Watch: how LT(S)ER is safeguarding Southern Africa's people and biodiversity for a sustainable Mountain future, Land. (Basel) 10 (10) (2021) 1024, https://doi.org/10.3390/land10101024.

[19] FAO, Climate-Resilient Fish Breeds in Uganda's Aquaculture Sector, Food and Agriculture Organization, (2021). https://www.fao.org/fishery/en/country sector/naso_uganda. accessed February 15, 2025.

[20] J. Rockström, O. Edenhofer, J. Gaertner, F. DeClerck, Planet-proofing the Global food system, Nat. Food 1 (1) (2020) 3–5, https://doi.org/10.1038/s43016-019-0010-4.

[21] J. Pretty, T.G. Benton, Z.P Bharucha, et al., Global assessment of agricultural system redesign for sustainable intensification, Nat. Sustain. 1 (8) (2018) 441–446, https://doi.org/10.1038/s41893-018-0114-0.

[22] J.W. Oltjen, J.L. Beckett, Role of ruminant livestock in sustainable agricultural systems, J. Anim. Sci. 74 (6) (1996) 1406, https://doi.org/10.2527/1996.7461406x.

[23] L. Reisch, U. Eberle, S. Lorek, Sustainable food consumption: an overview of contemporary issues and policies, Sustain.: Sci. Pract. Policy 9 (2) (2013) 7–25, https://doi.org/10.1080/15487733.2013.11908111.

[24] M. Herrero, P.K. Thornton, D. Mason-D'Croz, et al., Innovation can accelerate the transition towards a sustainable food system, Nat. Food 1 (5) (2020) 266–272, https://doi.org/10.1038/s43016-020-0074-1.

[25] H. Eswaran, R. Lal, P.F. Reich, Land degradation: an overview, in: 1st ed., CRC Press, England, 2019 https://doi.org/10.1201/9780429187957-4.

[26] I. Elouafi, Why biodiversity matters in agriculture and food systems, Science (1979) 386 (6718) (2024) eads8197, https://doi.org/10.1126/science.ads8197.

[27] S.R. Weiskopf, M.A. Rubenstein, L.G. Crozier, et al., Climate change effects on biodiversity, ecosystems, ecosystem services, and natural resource management in the United States, Sci. Total Environ. 733 (September) (2020) 137782, https://doi.org/10.1016/j.scitotenv.2020.137782.

[28] E. Grigorieva, A. Livenets, E. Stelmakh, Adaptation of agriculture to Climate change: a scoping review, Climate 11 (10) (2023) 202, https://doi.org/10.3390/cli11100202.

[29] Y.-J. Shin, G.F. Midgley, E.R.M. Archer, et al., Actions to halt biodiversity loss generally benefit the climate, Glob. Chang. Biol. 28 (9) (2022) 2846–2874, https://doi.org/10.1111/gcb.16109.

[30] A. Agarwal, D. Durairajanayagam, S. Tatagari, et al., Bibliometrics: tracking research impact by selecting the appropriate metrics, Asian J. Androl. 18 (2) (2016) 296, https://doi.org/10.4103/1008-682X.171582.

[31] V.K Singh, P. Singh, M. Karmakar, J. Leta, P. Mayr, The journal coverage of web of science, scopus and dimensions: a comparative analysis, Scientometrics 126 (6) (2021) 5113–5142, https://doi.org/10.1007/s11192-021-03948-5.

[32] R Core Team, R: A Language and Environment for Statistical Computing. Version 4.4.2 [software]. https://www.R-project.org/.

[33] A.D. Mazaris, C. Gkazinou, V. Almpanidou, G. Balazs, The sociology of Sea turtle research: evidence on a global expansion of Co-authorship networks, Biodivers. Conserv. 27 (6) (2018) 1503–1516, https://doi.org/10.1007/s10531-018-1506-1.

[34] Shilpa, S. Bhattacharya, Indo-French cooperation In Water sciences: capturing research dynamics through Co-authorship analysis, Curr. Sci. 113 (09) (2017) 1668, https://doi.org/10.18520/cs/v113/i09/1668-1674.

[35] H. Wickham, R. Francois, L. Henry, K. Muller, D. Vaughan, Dplyr: A Grammar of Data Manipulation, R Package Version 1.1.4 [software], 2023. https://CRAN.R-project.org/package=dplyr.

[36] P. Poschlod, S. Bonn, Changing dispersal processes in the Central European landscape since the last Ice age: an explanation for the actual decrease of plant species richness in different habitats? Acta Bot. Neerl. 47 (1) (1998) 27–44. https://natuurtijdschriften.nl/pub/541120.

[37] K. Henle, D. Alard, J. Clitherow, et al., Identifying and managing the conflicts between agriculture and biodiversity conservation in Europe–A review, Agric. Ecosyst. Environ. 124 (1–2) (2008) 60–71, https://doi.org/10.1016/j.agee.2007.09.005.

[38] A.S. MacDougall, K.S. McCann, G. Gellner, R. Turkington, Diversity loss with persistent Human disturbance increases vulnerability to ecosystem collapse, Nature 494 (7435) (2013) 86–89, https://doi.org/10.1038/nature11869.

[39] B. Clergue, B. Amiaud, F. Pervanchon, F. Lasserre-Joulin, S. Plantureux, Biodiversity: function and assessment in agricultural areas: a review, in: E. Lichtfouse, M. Navarrete, P. Debaeke, S. Véronique, C. Alberola (Eds.), Sustainable Agriculture, Springer, Netherlands, 2009, https://doi.org/10.1007/978-90-481-2666-8_21.

[40] Williams, M.J. Food from the water: how the fish production revolution affects aquatic biodiversity and Food security. (2010). https://doi.org/10.22004/AG.ECON.125247. accessed February 25, 2025.

[41] T. Garlock, F. Asche, J. Anderson, et al., A global blue revolution: aquaculture growth across regions, species, and countries, Rev. Fish. Sci. Aquac. 28 (1) (2020) 107–116, https://doi.org/10.1080/23308249.2019.1678111.

[42] G.A. Ajeagah, W.V.B. Abanda, G.E. Nkeng, An application of a water assessment and simulation model in the remediation of the eutrophication capacity of a tropical water system: case study the Lake Obili in Yaounde (Cameroon), J. Water Land Dev. 33 (1) (2017) 11–22, https://doi.org/10.1515/jwld-2017-0014.

[43] Z. Reta Roba, M.B Moisa, S. Purohit, K.T Deribew, D.O Gemeda, Assessment of soil erosion and sediment yield in response to land use and land cover changes using geospatial techniques in Dumuga Watershed, Ethiopia, All Earth 37 (1) (2025) 1–18, https://doi.org/10.1080/27669645.2025.2460917.

[44] B.C Tumsa, F.F Feyessa, K.T Tullu, A.C Guder, Spatiotemporal changes of land use in response to runoff and sediment yield for environmental sustainability in the Upper Blue Nile Basin, Oromiyaa, Ethiopia, H2Open J. 6 (4) (2023) 551–575, https://doi.org/10.2166/h2oj.2023.072.

[45] M. Mng'ong'o, L.K. Munishi, W. Blake, S. Comber, T.H. Hutchinson, P. A. Ndakidemi, Towards sustainability: threat of water quality degradation and eutrophication in Usangu Agro-Ecosystem Tanzania, Mar. Pollut. Bull. 181 (August) (2022) 113909, https://doi.org/10.1016/j.marpolbul.2022.113909.

[46] P.K. Yadav, R. Sachan, D.K. Dwivedi, Ecological consequences: understanding the effects of agricultural pollution on ecosystem, wildlife, and biodiversity, in: K. Singn, A. Kumar, D. Kumar, R. Kumar (Eds.), A Comprehensive Exploration of Soil, Water, and Air Pollution in Agriculture, BFC Publications Private Limited, Gomti Nagar, India, 2024, pp. 139–153.

[47] S.A. Mesele, M. Mechri, M.A. Okon, et al., Current problems leading to soil degradation in Africa: raising awareness and finding potential solutions, Eur. J. Soil. Sci. 76 (1) (2025) e70069, https://doi.org/10.1111/ejss.70069.

[48] A. Legesse, M. Negash, Species diversity, composition, structure and management in agroforestry systems: the case of Kachabira District, Southern Ethiopia, Heliyon 7 (3) (2021) e06477, https://doi.org/10.1016/j.heliyon.2021.e06477.

[49] G. Sossa, C. Leonce, J.B. Naab, S. Sanogo, M. Asante, K.S. Sambieni, L. O. Sintondji, Moderate N fertilizer inputs under proper water management enhanced off-season rice production in Central Benin, West Africa, Irrig. Sci. 43 (2025) 433–448, https://doi.org/10.1007/s00271-024-00965-z, ahead of print, August 8.

[50] E. Barrios, V. Valencia, M. Jonsson, et al., Contribution of trees to the conservation of biodiversity and ecosystem services in agricultural landscapes, Int. J. Biodivers. Sci. Ecosyst. Serv. Manage 14 (1) (2018) 1–16, https://doi.org/10.1080/21513732.2017.1399167.

[51] S.E. Castle, D.C. Miller, P.J. Ordonez, K. Baylis, K. Hughes, The impacts of agroforestry interventions on agricultural productivity, ecosystem services, and Human well-being in low- and middle-income countries: a systematic review, Campbell. Syst. Rev. 17 (2) (2021) e1167, https://doi.org/10.1002/cl2.1167.

[52] P. Smith, P.J. Gregory, D. Van Vuuren, et al., Competition for land, Philos. Trans. R. Soc. B: Biol. Sci. 365 (1554) (2010) 2941–2957, https://doi.org/10.1098/rstb.2010.0127.

[53] P.R. Oyono, T.L. Morelli, J. Sayer, et al., Allocation and use of forest land: current trends, issues and perspectives, in: C. de Wasseige, J. Flynn, D. Louppe, F. Hiol Hiol, Mayaux Ph (Eds.), Forests of the Congo Basin–State of the Forests, OFAC, Washington, D.C, 2013, pp. 215–240.

[54] P.E. Peters, Land appropriation, surplus people and a battle over visions of agrarian futures in Africa, J. Peasant Stud. 40 (3) (2013) 537–562, https://doi.org/10.1080/03066150.2013.803070.
[55] B. White, S.M. Borras Jr., R. Hall, I. Scoones, W. Wolford, The new Enclosures: critical perspectives on corporate land deals, J. Peasant. Stud. 39 (3–4) (2012) 619–647, https://doi.org/10.1080/03066150.2012.691879.
[56] A. Kainyande, K.S. Hintz, S. Kyamagero, E. Auch, L. Giessen, Reviewing the ambiguity in the socio-economic outcomes of large-scale tree plantation investments: reconciling decades of contrasting evidence from Sub-Saharan Africa, Int. For. Rev. 26 (4) (2024) 470–489, https://doi.org/10.1505/146554824839334696.
[57] L. Zvobgo, J. Tsoka, Deforestation rate and causes in upper Manyame Sub-catchment, Zimbabwe: implications on achieving national climate change mitigation targets, Trees. For. People 5 (September) (2021) 100090, https://doi.org/10.1016/j.tfp.2021.100090.
[58] OECD, Enhancing the Mitigation of Climate Change Though Agriculture: Policies, Economic Consequences, and Trade-Offs, OECD, (2019). https://doi.org/10.1787/e9a79226-en. accessed January 25, 20025.
[59] D.W. Sintayehu, Impact of climate change on biodiversity and associated key ecosystem services in Africa: a systematic review, Ecosyst. Health Sustain. 4 (9) (2018) 225–239, https://doi.org/10.1080/20964129.2018.1530054.
[60] M.G Muluneh, Impact of climate change on biodiversity and food security: a global perspective—a review article, Agric. Food Secur. 10 (1) (2021) 36, https://doi.org/10.1186/s40066-021-00318-5.
[61] F. Abbas, H.M Hammad, S. Fahad, et al., Agroforestry: a sustainable environmental practice for carbon sequestration under the climate change scenarios—a review, Environ. Sci. Pollut. Res. 24 (12) (2017) 11177–11191, https://doi.org/10.1007/s11356-017-8687-0.
[62] K.J.J. Kuipers, J.P. Hilbers, J. Garcia-Ulloa, et al., Habitat fragmentation amplifies threats from habitat loss to mammal diversity across the world's terrestrial ecoregions, One Earth. 4 (10) (2021) 1505–1513, https://doi.org/10.1016/j.oneear.2021.09.005.
[63] P. Kumar Rai, J.S. Singh, Invasive alien plant species: their impact on environment, ecosystem services and Human health, Ecol. Indic. 111 (April) (2020) 106020, https://doi.org/10.1016/j.ecolind.2019.106020.
[64] P.K Rai, Environmental degradation by invasive alien plants in the anthropocene: challenges and prospects for sustainable restoration, Anthr. Sci. 1 (1) (2022) 5–28, https://doi.org/10.1007/s44177-021-00004-y.
[65] R. Biggs, S.R. Carpenter, W.A. Brock, Turning back from the brink: detecting an impending regime shift in time to avert it, Proc. Natl. Acad. Sci. USA 106 (3) (2009) 826–831, https://doi.org/10.1073/pnas.0811729106.
[66] R.K. Didham, J.M. Tylianakis, M.A. Hutchison, R.M. Ewers, N.J. Gemmell, Are invasive species the drivers of ecological change? Trends Ecol. Evol. (Amst.) 20 (9) (2005) 470–474, https://doi.org/10.1016/j.tree.2005.07.006.
[67] M. Gaertner, R. Biggs, M. Te Beest, C. Hui, J. Molofsky, D.M. Richardson, Invasive plants as drivers of regime shifts: identifying high-priority invaders that alter feedback relationships, Divers. Distrib. 20 (7) (2014) 733–744, https://doi.org/10.1111/ddi.12182.
[68] D.J. Fuerte-Velázquez, A. Gómez-Tagle, Water footprint and Water sustainability of agroindustrial Avocado production in a warm tropical climate municipality: a case study in the Michoacan Avocado Belt in Central México, Water (Basel) 16 (12) (2024) 1719, https://doi.org/10.3390/w16121719.
[69] G. Teshome, A. Getahun, M. Mingist, G. Wilson, W. Anteneh, Influence of irrigation infrastructures and water quality on fish assemblages in Lake Tana Tributaries, North-West Ethiopia, Environ. Biol. Fishes. 104 (6) (2021) 653–673, https://doi.org/10.1007/s10641-021-01101-y.
[70] FAO, The Future of Food and Agriculture – Trends and Challenges, Food and Agriculture Organization of the United Nations, Rome, (2017). http://www.fao.org/3/a-i6583e.pdf. accessed February 5, 2025.
[71] T. Lukhele, T.AM. Msagati, Eutrophication of inland surface waters in South Africa: an overview, Int. J. Environ. Res. 18 (2) (2024) 27, https://doi.org/10.1007/s41742-024-00568-8.
[72] P.M. Nyenje, J.W. Foppen, S. Uhlenbrook, R. Kulabako, A. Muwanga, Eutrophication and nutrient release in urban areas of Sub-Saharan Africa — a review, Sci. Total Environ. 408 (3) (2010) 447–455, https://doi.org/10.1016/j.scitotenv.2009.10.020.
[73] O. Amogu, M. Esteves, J.-P. Vandervaere, et al., Runoff evolution due to land-use change in a small Sahelian catchment, Hydrol. Sci. J. 60 (1) (2015) 78–95, https://doi.org/10.1080/02626667.2014.885654.
[74] F. Karamage, Y. Liu, Y. Liu, Data construction and spatiotemporal trend attribution of runoff over the African continent (1981–2016), J. Hydrometeorol 22 (8) (2021) 1949– 1971, https://doi.org/10.1175/JHM-D-20-0143.1.
[75] H. Mwanake, B. Mehdi-Schulz, K. Schulz, et al., Agricultural practices and soil and water conservation in the transboundary region of Kenya and Uganda: farmers' Perspectives of current soil erosion, Agriculture 13 (7) (2023) 1434, https://doi.org/10.3390/agriculture13071434.
[76] E. Roose, Land Husbandry: Components and Strategy, FAO, Rome, (1996), p.no. 70. https://share.google/saoTeXfDCrSVUOgn7. accessed February 29, 2025.
[77] F. Franchi, S. Mustafa, D. Ariztegui, et al., Prolonged drought periods over the last four decades increase flood intensity in Southern Africa, Sci. Total Environ. 924 (May) (2024) 171489, https://doi.org/10.1016/j.scitotenv.2024.171489.
[78] L. Caramel, From Guinea to Chad, floods affect 3.5 million people, killing nearly 900, Le Monde (Paris) (2024). https://www.lemonde.fr/en/le-monde-africa/article/2024/09/12/from-guinea-to-chad-floods-affect-3-5-million-people-killing-nearly-900_6725832_124.html. accessed February 15, 2025.
[79] C.M. McBride, A.C. Kruger, L. Dyson, Changes in extreme daily rainfall characteristics in South Africa: 1921–2020, Weather. Clim. Extrem. 38 (December) (2022) 100517, https://doi.org/10.1016/j.wace.2022.100517.
[80] M. Zachariah, C. Barnes, C. Wainwright, et al., Climate change exacerbated heavy rainfall leading to large scale flooding in highly vulnerable communities in West Africa. (2022). https://www.worldweatherattribution.org/climate-change-exacerbated-heavy-rainfallleading-to-large-scale-flooding-in-highly-vulnerable-communities-in-west-africa/. accessed February 16, 2025.
[81] D. Teku, T. Derbib, Uncovering the drivers, impacts, and urgent solutions to soil erosion in the Ethiopian highlands: a global perspective on local challenges, Front. Environ. Sci. 12 (January) (2025) 1521611, https://doi.org/10.3389/fenvs.2024.1521611.
[82] J.J. Le Roux, T. Newby, P. Summer, Monitoring soil erosion in South Africa at a regional scale: review and recommendations. (2007). http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0038-23532007000400017&lng=en&tlng=en. accessed January 20, 2025.
[83] S. Sodoke, S.A Andam-Akorful, E.EY. Amuah, et al., GIS-based assessment of soil erosion impact and mitigation strategies for sustainable agriculture in Ghana's most vulnerable region, Environ. Sustain. Indic. 25 (February) (2025) 100551, https://doi.org/10.1016/j.indic.2024.100551.
[84] F. Mensah, S.K. Adanu, D.K. Adanu, Research article: remote sensing and GIS based assessment of land degradation and implications for Ghana's ecological zones, Environ. Pract. 17 (1) (2015) 3–15, https://doi.org/10.1017/S1466046614000465.
[85] W. Cristiano, C. Giacoma, M. Carere, L. Mancini, Chemical pollution as a driver of biodiversity loss and potential deterioration of ecosystem services in Eastern Africa: a critical review, S. Afr. J. Sci. 117 (2021) 9/10, https://doi.org/10.17159/sajs.2021/9541.
[86] United Nations, Water-insecure Africa gets some wins at the UN Water Conference, Africa Renewal, (2023). https://www.un.org/africarenewal/magazine/april-2023/water-insecure-africa-gets-some-wins-un-water-conference. accessed January 25, 2025.
[87] E.R. Jones, M.F.P. Bierkens, N. Wanders, E.H. Sutanudjaja, L.P.H. Van Beek, M.T. H. Van Vliet, DynQual v1.0: a high-resolution global surface water quality model, Geosci. Model. Dev. 16 (15) (2023) 4481–4500, https://doi.org/10.5194/gmd-16-4481-2023.
[88] Z. Shehu, G.WA. Nyakairu, E. Tebandeke, O.N Odume, Overview of African water resources contamination by contaminants of emerging concern, Sci. Total Environ. 852 (15) (2022) 158303, https://doi.org/10.1016/j.scitotenv.2022.158303.
[89] N. Kalischek, N. Lang, C.é Renier, et al., Cocoa plantations are associated with deforestation in Côte d'Ivoire and Ghana, Nat. Food 4 (5) (2023) 384–393, https://doi.org/10.1038/s43016-023-00751-8.
[90] S. Hansen, F. Roets, C.L. Seymour, E. Thébault, F.J.F. Van Veen, J.S. Pryke, Alien plants have greater impact than habitat fragmentation on native insect flower visitation net-works, Divers. Distrib. 24 (1) (2018) 58–68, https://doi.org/10.1111/ddi.12656.
[91] J.érôE. Tondoh, F.ç N'guessan Kouamé, A.M Guéi, B. Sey, A.W Koné, N. oël Gnessougou, Ecological changes induced by full-sun cocoa farming in Côte d'Ivoire, Glob. Ecol. Conserv. 3 (January) (2015) 575–595, https://doi.org/10.1016/j.gecco.2015.02.007.
[92] C. Kremen, N.M. Williams, R.W. Thorp, Crop pollination from native bees at risk from agricultural intensification, Proc. Natl. Acad. Sci. USA 99 (26) (2002) 16812–16816, https://doi.org/10.1073/pnas.262413599.
[93] T. Tscharntke, A.M. Klein, A. Kruess, I. Steffan-Dewenter, C. Thies, Land-scape perspectives on agricultural intensification and biodiversity – Ecosystem service management, Ecol. Lett. 8 (8) (2005) 857–874, https://doi.org/10.1111/j.1461-0248.2005.00782.x.
[94] A.J Vanbergen, The Insect Pollinators Initiative, Threats to an ecosystem service: pressures on pollinators, Front. Ecol. Environ. 11 (5) (2013) 251–259, https://doi.org/10.1890/120126.
[95] B.ît Geslin, M. Oddie, M. Folschweiller, et al., Spatiotemporal changes in flying insect abun-dance and their functional diversity as a function of distance to natural habitats in a mass flowering crop, Agric. Ecosyst. Environ. 229 (August) (2016) 21–29, https://doi.org/10.1016/j.agee.2016.05.010.
[96] J. John, E. Mgimwa, E. Kamugisha, A. Rabdiya, Feathered frontiers: how land-use changes shape diversity of bird communities in an East African global biodiversity hotspot, Afr. J. Ecol. 63 (2) (2025) e70024, https://doi.org/10.1111/aje.70024.
[97] J. Liang, T. Reynolds, A. Wassie, C. Collins, A. Wubalem, 1 Environmental Studies Program, Colby College, Waterville, ME 04901, USA, Effects of exotic Eucalyptus spp. Plantations on soil properties in and around sacred natural sites in the northern Ethiopian Highlands, AIMS Agric. Food 1 (2) (2016) 175–193, https://doi.org/10.3934/agrfood.2016.2.175.
[98] J.E. Tondoh, K. Dimobe, A.M. Guéi, L. Adahe, Y. Baidai, J.K. N'Dri, G. Forkuor, Soil health changes over a 25-Year chronosequence from forest to plantations in rubber tree (Hevea brasiliensis) landscapes in Southern Côte d'Ivoire: Do Earthworms Play a Role? Front. Environ. Sci. 7 (2019) 73, https://doi.org/10.3389/fenvs.2019.00073.
[99] K. Yeo, S. Konate, S. Tiho, S.K. Camara, Impacts of land use types on ant communities in a tropical forest margin (Oumé – Côte d ' Ivoire), Afr. J. Agric. Res. 6 (2) (2011) 260–274.
[100] H.O. Mangi, S.M. Onywere, E.C. Kitur, Fish productivity response to Water quality variations: a case study of Nyumba Ya Mungu Dam, in Pangani Water Basin, Tanzania, Int. J. Ecol. 2023 (July) (2023) 1–11, https://doi.org/10.1155/2023/7353898.

[101] O.C Ochieng, G.M Ogendi, N.S Donia, Spatial variation in physicochemical water quality parameters associated with rice farming in the Dakalt Branch Canal, Kafrelsheikh Governorate, Egypt, World Water Policy 11 (1) (2025) 289–303, https://doi.org/10.1002/wwp2.12232.
[102] D.M. Njagi, J. Routh, M. Odhiambo, et al., A century of Human-induced environmental changes and the combined roles of nutrients and land use in Lake Victoria catchment on eutrophication, Sci. Total Environ. 835 (August) (2022) 155425, https://doi.org/10.1016/j.scitotenv.2022.155425.
[103] Z. Menberu, B. Mogesse, D. Reddythota, Evaluation of water quality and eutrophication status of Hawassa Lake based on different water quality indices, Appl. Water. Sci. 11 (3) (2021) 61, https://doi.org/10.1007/s13201-021-01385-6.
[104] H. Tadesse, A. Lakew, A. Getahun, Community structure and habitat preferences of stream fish in major tributaries of the Upper Awash River, Ethiopia, J. Ecohydraul. 10 (2025) 356–365, https://doi.org/10.1080/24705357.2025.2462295.
[105] J. Bangre, S. Mandloi, M. Vishwakarma, Sustaining soil fertility: exploring the long-term effects of chemical fertilizers and farmyard manure application, Int. J. Plant Soil. Sci. 35 (21) (2023) 534–541, https://doi.org/10.9734/ijpss/2023/v35i214007.
[106] L.E. Drinkwater, S.S. Snapp, Advancing the science and practice of ecological nutrient management for smallholder farmers, Front. Sustain. Food Syst. 6 (September) (2022) 921216, https://doi.org/10.3389/fsufs.2022.921216.
[107] F.B Santojanni, H. Miner, H. Hain, G. Sutton, The impact of climate change on biodiversity in coastal ecosystems, J. Ilmu Pendidik. Dan Hum. 12 (3) (2023) 167–182, https://doi.org/10.35335/jiph.v12i3.9.
[108] S. Díaz, U. Pascual, M. Stenseke, et al., Assessing nature's contributions to people, Science (1979) 359 (6373) (2018) 270–272, https://doi.org/10.1126/science.aap8826.