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Soil Erosion in Southwestern Niger: Biophysical Drivers, Anthropogenic Pressures and Pathways to Land Restoration

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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Abstract

Southwestern Niger, a densely settled corridor of the West African Sahel centred on the Niamey region, has become one of the most intensively studied landscapes for understanding dryland soil erosion. Four decades of hydrological monitoring, wind-tunnel and field experimentation, remote sensing and rural livelihood research have produced a substantial body of evidence on how wind erosion, surface crusting, water erosion and gully dynamics interact with rapid population growth, cropland expansion and the retreat of fallow and woodland cover. This review synthesises that evidence to characterise the principal erosive processes operating in the region, the land use and demographic forces that have intensified them since the mid-

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twentieth century, their consequences for crop productivity, groundwater recharge and river sediment loads, the indigenous and introduced soil, along with water conservation techniques that have been deployed in response. Particular attention is given to the coexistence of a regional vegetation "greening" trend with persistent and, in places, worsening local degradation, a paradox that has reshaped scientific and policy debate over the past two decades. The review further considers the institutional and socio-economic conditions that govern the adoption of conservation practices such as zaï, half-moons and Faidherbia albida-based parklands, and closes with an assessment of research and policy priorities, the principal conclusions to be drawn from the accumulated literature, and the limitations inherent in a narrative synthesis of fragmented and methodologically heterogeneous evidence.

Keywords: Soil erosion; wind erosion; Sahel; Niger; land degradation; soil and water conservation; land use change; groundwater recharge.

1. Introduction

1.1 The Sahelian Erosion Problem and Its Regional Expression

The West African Sahel has occupied a prominent place in the global land degradation literature since the severe droughts of the late 1960s to the 1980s, when widespread crop failure, livestock mortality and population displacement were widely attributed to a combination of rainfall deficit and unsustainable land management (Warren et al., 2001). Southwestern Niger, encompassing the Niamey region and the surrounding Fakara, Kollo and Say departments, has served as one of the principal field laboratories for this research agenda, owing to the presence of long-running international monitoring programmes at sites such as Banizoumbou, Wankama, Sadoré and Hamdallaye (Pierre et al., 2022). The region is characterised by low and highly variable annual rainfall, typically between 400 and 600 millimetres, concentrated in a three- to four-month wet season, overlying predominantly sandy Aerosols that are inherently susceptible to both wind and water erosion once their thin organic surface layer and vegetative cover are disturbed (Bielders et al., 2000). Two distinct but interacting erosive regimes dominate: wind erosion, which strips the finest and most fertile soil fractions from bare cultivated fields during the early rainy season and the dry Harmattan period, and water erosion, driven by surface crusting that sharply reduces infiltration and generates runoff even under moderate storm intensities (Chappell et al., 1998). Recent experimental evidence from Niger indicates that the loss of the thin surface horizon can reduce pearl millet productivity by limiting plant-available water and nutrients, illustrating a direct pathway from erosion to agricultural loss (Nishigaki et al., 2025).

1.2 Biophysical and Demographic Context

The landscapes of southwestern Niger typically comprise a catena of lateritic plateaux historically covered by a banded shrub vegetation known locally as broussetigrée, or tiger bush, descending through erosion glacis to cultivated valley bottoms and temporary ponds (Wu et al., 2000). This geomorphological arrangement has a strong bearing on erosion dynamics, since the plateaux act as water-generating surfaces whose runoff is transmitted downslope to the cultivated glacis, where crusting, tillage and residue removal further amplify soil loss (Warren et al., 2003). Since the 1950s the region has experienced a sustained demographic expansion, with population growth rates in Niger among the highest recorded globally, which has driven a substantial extension of cultivated area at the expense of fallow, woodland and tiger bush, and a corresponding shortening of fallow cycles that once allowed vegetative and structural recovery of the soil surface (Leblanc et al., 2008). These land use trajectories, superimposed on a climate that experienced severe drying between the late 1960s and mid-1980s followed by a partial rainfall recovery from the 1990s onward, have generated one of the more intensively documented case studies of coupled human-environment change in the drylands. Recent field observations from western Niger show that woody plant decline can persist despite a broader Sahelian greening signal, while cropland expansion, shorter fallow cycles and pressure on wood resources were identified as plausible contributors (Hiernaux et al., 2022). Satellite-based assessment of the Dosso Reserve similarly linked local vegetation browning primarily to soil-moisture constraints and land-use/land-cover change, reinforcing the need to distinguish site-level degradation from regional vegetation trends (Zeng et al., 2024). At the national scale, the uneven spatial distribution of documented degraded-land reclamation actions has highlighted the value of georeferenced monitoring for better targeting and coordination of restoration interventions (Sadda et al., 2023).

1.3 Scope, Research Gap and Objectives

The literature on soil erosion in southwestern Niger spans several disciplinary traditions, including agronomy, hydrology, geomorphology, remote sensing and political ecology, which have not always been synthesised within a single framework. Much of the biophysical process literature dates from intensive field campaigns conducted between the 1990s and the 2010s, while more recent contributions have shifted toward satellite-based vegetation monitoring, hydrological modelling of groundwater recharge, and evaluation of large-scale land restoration programmes financed by international donors. A persistent tension runs through this body of work between regional narratives of Sahelian "re-greening", derived largely from coarse-resolution vegetation indices, and site-level evidence of continued or even accelerating degradation on cultivated fields, grazed plateaux and gully-affected valley networks. This apparent contradiction has not been fully reconciled in prior reviews, several of which have focused narrowly on either the biophysical mechanics of wind and water erosion or on the socio-economic dimensions of land management, without integrating the two. The present review addresses this gap by drawing together the biophysical, hydrological, agronomic and institutional strands of the literature specific to southwestern Niger, in order to characterise the principal processes and drivers of erosion in the region, evaluate the evidence on its consequences for agricultural productivity, water resources and river systems, assess the performance and adoption of indigenous and introduced conservation measures, and identify the research and policy priorities that follow from this synthesis. The review is confined to the semi-arid belt of southwestern Niger, broadly the Niamey, Kollo, Say, Tillabéri and Dosso departments, and does not extend systematically to the wider Sahel except where regional studies are required to contextualise site-specific findings.

2. Methods for Literature Selection

2.1 Databases and Search Strategy

Literature was identified through structured searches of Web of Science, Scopus and Google Scholar, supplemented by targeted searches of PubMed, where relevant to health and dust-exposure dimensions of wind erosion, and of five field-specific indexing resources: AGRICOLA, CAB Abstracts, GeoRef, the AGRIS repository of the Food and Agriculture Organization, and the horizon repository of the Institut de Recherche pour le Développement, which holds a substantial share of francophone Sahelian soil science literature not fully indexed elsewhere. Search strings combined geographic terms ("Niger" OR "Sahel" OR "Niamey" OR "Fakara" OR "Sadoré" OR "Banizoumbou" OR "Wankama") with process and thematic terms ("soil erosion" OR "wind erosion" OR "water erosion" OR "land degradation" OR "soil crusting" OR "gully erosion" OR "runoff" OR "groundwater recharge" OR "land use change" OR "soil and water conservation" OR "zaï" OR "half-moon" OR "Faidherbia"). Boolean combinations were run iteratively, with results screened by title and abstract before full-text retrieval.

2.2 Rationale for a Narrative Rather than Systematic Review Approach

A narrative review format was adopted in preference to a systematic review, for three principal reasons. First, the evidence base spans heterogeneous methodologies, ranging from plot-scale wind-tunnel and rainfall-simulation experiments to catchment-scale hydrological modelling, satellite vegetation index analysis and rural livelihood surveys, precluding meaningful meta-analytic pooling of quantitative outcomes. Second, the review question is deliberately broad and integrative, seeking to connect biophysical, hydrological and socio-institutional literatures rather than to answer a single narrowly defined effectiveness question, a purpose for which narrative synthesis is widely considered more appropriate than a systematic protocol (Greenhalgh et al., 2018). Third, much of the regionally specific literature, particularly francophone field studies conducted through the AMMA-CATCH and ICRISAT Sahelian Centre programmes, is dispersed across institutional repositories and thematic journals that a narrow systematic protocol with rigid inclusion filters risks excluding. Systematic and narrative reviews are best regarded as complementary rather than hierarchically ranked forms of evidence synthesis, and the present exercise follows the latter tradition while retaining transparent reporting of search terms, sources and selection criteria.

2.3 Screening, Duplicate Handling and Language Considerations

Titles and abstracts retrieved from each database were compiled and de-duplicated by comparing digital object identifiers and, where these were absent, by comparing author names, titles and publication years. Both Englishand French-language sources were eligible for screening, reflecting the bilingual character of Sahelian research output, although only claims traceable to a verifiable English-language peer-reviewed full text were retained for detailed citation in the present article; French-language sources encountered during screening informed general contextual understanding but are not cited as the basis for specific quantitative claims.

2.4 Inclusion and Exclusion Criteria and Selection of Influential Studies

Eligible sources comprised peer-reviewed journal articles published in indexed international journals, together with a small number of authoritative institutional reports from United Nations agencies and comparable bodies, cited where they provided verifiable data unavailable in the peer-reviewed literature. Books, book chapters, conference proceedings, unpublished theses, pre-prints, patents and trade or grey literature were excluded, consistent with the objective of grounding the review in verifiable, peer-reviewed evidence. Influential older studies, several dating from the 1990s, were retained where they established methodological or conceptual foundations still cited in the contemporary literature, on the understanding that a purely recency-restricted search would misrepresent the historical depth of process understanding in this region. Priority in citation was given to studies conducted at named field sites within the study region, to studies with quantitative erosion or hydrological measurements, and to review or synthesis articles that themselves drew on a wide primary literature. The search covered publications from January 2000 to 30 March 2026.

3. Biophysical Drivers of Soil Erosion

3.1 Wind Erosion Processes

Wind erosion is widely regarded, in the experimental literature from the ICRISAT Sahelian Centre near Niamey, as the dominant erosive process on cultivated sandy fields during the early rainy season, when tillage and clearing leave the soil surface unprotected by residues or standing vegetation (Michels et al., 1993). Sand-laden winds preceding the first storms of the season can bury newly sown millet pockets entirely, forcing farmers to resow, while surviving seedlings show delayed emergence and stunted growth, a pattern documented through repeated sand-trap measurements at experimental sites (Michels et al., 1993). Because wind erosion selectively removes the finest silt, clay and organic matter fractions, it disproportionately depletes the nutrient pool of already nutrient-poor Sahelian sands, an effect confirmed through repeated field measurement of crop residues and soil flux under traditional field management (Abdourhamane Touré et al., 2011). Field experiments manipulating crop residue cover have shown that even modest quantities of millet stover, laid flat on the soil surface after harvest, substantially reduce horizontal sediment flux, although the protective effect declines rapidly once residue cover falls below roughly five hundred kilograms per hectare, a threshold regularly breached under contemporary grazing and fuelwood collection pressure (Abdourhamane Touré et al., 2011). On-farm trials combining ridging with banded or broadcast residue mulching found that broadcast mulching provided the most effective and direction-independent control of wind erosion among the practices tested (Bielders et al., 2000). Land use itself shapes erodibility in ways that are not always intuitive: recent flux monitoring on a representative dune ridge in southwestern Niger found that rangeland surfaces produced at least twice the horizontal erosion flux and saltation of adjacent millet fields under comparable wind conditions, the first such demonstration in the Sahel that grazed rangeland can be more erodible than cultivated land, with clear implications for how grazing pressure rather than cultivation alone should be prioritised in erosion control planning (Ide et al., 2025). More recent process-based modelling extending earlier findings to future land management scenarios indicates that continued agro-pastoral intensification, involving expansion of cropland at the expense of fallow and more thorough removal of crop residues for livestock feed, would increase horizontal sediment flux several-fold relative to conditions prevailing in the 1990s (Pierre et al., 2022). These process-level findings are summarised in Table 1.

3.2 Water Erosion, Soil Crusting and Hydrological Response

Water erosion in the region is closely bound to the formation of physical and biological surface crusts on the predominantly sandy soils, a process first systematically described for Sahelian conditions in the 1980s and subsequently confirmed across numerous sites in Niger, Mali and Burkina Faso (Warren et al., 2003). Crusting sharply reduces water infiltration capacity, generating Hortonian overland flow even from rainfall events of modest intensity, with estimates for cultivated glacis land in Niger suggesting that a substantial share of seasonal rainfall, on the order of ten to twenty-five per cent depending on slope and surface condition, is lost as runoff rather than infiltrating to support crop growth (Warren et al., 2003). Radionuclide caesium-137 tracing conducted on village lands near Fandou Béri estimated net soil redistribution rates exceeding thirty tonnes per hectare per year at eroding locations, figures that substantially exceeded earlier regional estimates used to characterise the Sahel as an erosion "hot spot", while simultaneously identifying zones of net soil accumulation beneath woody vegetation, illustrating the strongly patchy, redistributive rather than uniformly depletive character of erosion at the landscape scale (Chappell et al., 1998). Farmer perception surveys conducted at the same site found that local Djerma and Fulani cultivators were often more concerned with the loss of soil fertility than with soil loss per se, a distinction that has shaped subsequent research emphasising nutrient rather than mass balance as the more policy-relevant erosion metric (Warren et al., 2001).

3.3 Geomorphological Setting: Plateaux, Glacis and Tiger Bush

The characteristic catena of southwestern Niger, comprising ferricrete-capped plateaux, erosion glacis and valley-bottom depressions, exerts a strong control on the spatial organisation of erosion and deposition. Plateaux historically supported the banded tiger bush vegetation pattern, in which alternating bands of dense woody thicket and bare crusted interband generate an efficient runoff-runon system that concentrates limited rainfall onto the vegetated bands, sustaining productivity under low rainfall while the bands themselves act as natural bench structures limiting soil loss (Wu et al., 2000). Long-term aerial photograph analysis covering the period from 1960 to 1992 demonstrated substantial fragmentation of these banded landscapes, evidenced by reduced woody cover and increased heterogeneity of vegetation patches, a change attributed principally to intensified grazing and fuelwood harvesting that opened runoff pathways through previously continuous vegetation bands (Wu et al., 2000). More recent satellite-based analysis combining Moderate Resolution Imaging Spectroradiometer and Landsat imagery over a tiger bush plateau near Niamey found that this land clearing process, driven substantially by urban fuelwood demand, remained ongoing between 2000 and 2015, with bare soil cover on the plateau expanding from approximately one quarter to over half of the study area between 1986 and 2012, and with the most severe degradation concentrated nearer to Niamey and toward the outer margins of the plateau (Fiorillo et al., 2017). Table 1 summarises the principal erosive processes and their documented magnitudes across these three biophysical domains.

Table 1. Principal erosive processes documented in southwestern Niger

Process	Key mechanism	Representative quantitative finding	Source
Wind erosion on cultivated fields	Removal of unprotected sandy topsoil during early rainy season and Harmattan winds	Single erosion events trapped over 380 kilograms per square metre of sand at ICRISAT Sahelian Centre plots	Michels et al. (1993)
Wind erosion under crop residue management	Reduced trapping efficiency below approximately 500 kilograms per hectare of residue	Broadcast millet stover mulching most effective, direction-independent control measure	Bielders et al. (2000)
Relative erodibility of rangeland versus cropland	Grazing-induced reduction of protective vegetation cover on rangeland	Horizontal erosion flux and saltation at least twofold greater on rangeland than on adjacent millet fields	Ide et al. (2025)
Water erosion and net soil redistribution	Surface crusting, reduced infiltration, Hortonian runoff	Net soil loss exceeding 30 tonnes per hectare per year at eroding village-land sites	Chappell et al. (1998)
Landscape-scale wind erosion under land use intensification	Loss of fallow and vegetation cover with cropland expansion	Modelled horizontal sediment flux rising from nil (1950s) to over 450 kilograms per metre per year under 2030s intensification scenarios	Pierre et al. (2022)
Tiger bush plateau degradation	Fragmentation of banded vegetation, loss of natural bench structures	Bare soil cover increased from approximately 25 per cent to 56 per cent of a plateau area between 1986 and 2012	Fiorillo et al. (2017)

4. Land Use Change and Anthropogenic Drivers

4.1 Demographic Pressure and Cropland Expansion

The intensification of erosion in southwestern Niger over the second half of the twentieth century is closely associated with rapid population growth and the consequent expansion of rainfed cropland into areas previously under fallow, woodland or extensive pastoral use. Analysis of aerial photography for a representative catchment near Niamey found that land clearance proceeded rapidly from the 1950s onward, with the areal extent of cultivated land increasing markedly and gully networks correspondingly lengthening and multiplying over the same period (Leblanc et al., 2008). This clearance has been closely linked to a documented decline in fallow duration, itself a response to demographic pressure on a fixed land resource, which curtails the vegetative and structural recovery of soil surfaces between cropping cycles and perpetuates a cycle of crusting, low infiltration and further nutrient export through both wind and water erosion (Warren et al., 2003).

4.2 Fuelwood Demand and Woodland Loss

Urban fuelwood demand from Niamey has been repeatedly identified as a distinct driver of vegetation loss on the plateaux surrounding the city, operating in addition to, and interacting with, agricultural clearance on the glacis below. The finding that degradation intensity on a monitored tiger bush plateau increased with proximity to Niamey, rather than being uniformly distributed, provides direct evidence that urban energy demand, rather than agricultural expansion alone, is shaping the spatial pattern of woodland loss in the wider region (Fiorillo et al., 2017). This dynamic has parallel consequences for parkland agroforestry systems, in which scattered trees of species such as Faidherbia albida are traditionally retained within cultivated fields for their soil fertility benefits; survey-based evidence from the Dogondoutchi parklands of southwestern Niger found that dieback of Faidherbia albida trees, associated in part with cutting pressure and environmental stress, was followed by grain yield reductions of between thirty-three and fifty-five per cent for the principal crops grown beneath the canopy, underscoring the productivity cost of woody cover loss (Tougiani et al., 2021).

4.3 Livestock Grazing and the Fragmentation of Protective Vegetation

Grazing pressure interacts with fuelwood harvesting in opening the banded vegetation structures characteristic of the region's plateaux, with elder residents at monitored sites explicitly attributing the fragmentation of tiger bush to increased grazing intensity and associated trampling and browsing that disrupt runoff pathways previously channelled through intact vegetation bands (Wu et al., 2000). Grazing pressure also acts directly on the erodibility of soil surfaces themselves, since livestock trampling and forage removal reduce the vegetative and crust-forming characteristics that would otherwise limit wind erosion on rangeland, a mechanism consistent with the finding that grazed rangeland can exhibit substantially higher wind erosion flux than adjacent cropland under equivalent meteorological conditions (Ide et al., 2025). The consequence is a self-reinforcing feedback in which the loss of protective vegetation increases runoff and surface crusting, further inhibiting the regeneration of the woody cover on which the original hydrological function depended, a dynamic evident both in historical aerial photograph series and in contemporary satellite monitoring. These anthropogenic drivers, and their documented erosion-related consequences, are summarised in Table 2.

4.4 The paradox of Hydrological Intensification Amid Drought

A distinctive feature of the southwestern Niger case is that the terrestrial water balance response to land clearance has, in several documented respects, exceeded the direct hydrological impact of the severe multi-decadal Sahelian drought that began in the late 1960s. Comparative analysis of aerial photographs and long-term hydrological records found that surface runoff and groundwater recharge both increased substantially over the four decades following the onset of land clearance, with the increase in recharge estimated at an order of magnitude, from approximately two millimetres per year prior to clearing to twenty-five millimetres per year or more thereafter, driven by the expansion and interconnection of ponds and gully networks that concentrate runoff into focused recharge points (Leblanc et al., 2008). This finding, that indirect hydrological effects of land use change outweighed the direct effects of rainfall decline, has become one of the most frequently cited results in the regional hydrology literature and has reframed subsequent research away from a purely climate-deterministic account of Sahelian land and water change toward one that gives land use change equal or greater explanatory weight.

Table 2. Anthropogenic drivers of land use change and their documented erosion-related consequences

Driver	Documented consequence	Study site or scope	Source
Demographic growth and cropland expansion	Rapid land clearance and gully network extension since the 1950s	Wankama catchment, southwestern Niger	Leblanc et al. (2008)
Fallow shortening	Reduced structural and vegetative recovery of soil surface between cropping cycles	Fandou Béri, southwestern Niger	Warren et al. (2003)
Urban fuelwood demand	Bare soil expansion greatest nearer Niamey; ongoing plateau clearance to 2015	Tiger bush plateau, South West Niger	Fiorillo et al. (2017)
Grazing and fuelwood harvesting on plateaux	Fragmentation of banded tiger bush vegetation between 1960 and 1992	Hamdallaye, southwestern Niger	Wu et al. (2000)
Grazing pressure on rangeland surfaces	Wind erosion flux at least twofold higher than adjacent cropland	Namaro dune ridge, southwestern Niger	Ide et al. (2025)
Parkland tree dieback	Grain yield reductions of 33–55 per cent following Faidherbia albida dieback	Dogondoutchi parklands, southwestern Niger	Tougiani et al. (2021)

5. Hydrological Consequences of Erosion and Land Use Change

5.1 Groundwater Recharge Dynamics

The rise in groundwater recharge associated with land clearance in southwestern Niger has been documented through multiple, complementary lines of evidence, including groundwater level monitoring, environmental tracer analysis and vadose zone modelling. Long-term piezometric records for the Niamey region show a mean groundwater level rise of approximately four metres between 1963 and 2005, corresponding to an estimated fifteen per cent increase in aquifer storage, a trend explained principally by the connectivity of newly formed gullies and ponds with the underlying aquifer rather than by any increase in rainfall, since this period coincided with the driest phase of the regional drought (Leblanc et al., 2008). Complementing this focused recharge pathway, vadose zone monitoring at paired fallow and rainfed millet cropland sites found that conversion of fallow to cropland increased both water content and matric potential to substantially greater depth beneath cultivated soil, with modelling indicating a diffuse drainage flux increase of around twenty-five millimetres per year expected to manifest at ten metres depth after a lag of several decades (Ibrahim et al., 2014). A complementary study of the transition from rainfed to irrigated cropping in the Komadugu Yobe valley of southeastern Niger (Lake Chad Basin) likewise indicated a further step-change increase in recharge associated with irrigation expansion, extending the same broad regional pattern to a different geomorphological setting (Le Coz et al., 2013). Collectively, these studies establish that the indirect hydrological legacy of erosion-related land use change, mediated through reduced evapotranspiration, increased runoff concentration and altered infiltration pathways, has become a dominant control on regional water resources, with implications both positive, in terms of augmented aquifer storage available for irrigation development, and negative, in terms of the erosive processes, including gully extension, that generate this recharge pathway in the first place.

5.2 Gully and Kori dynamics

The koris, or ephemeral drainage channels, of the Niamey region have undergone marked hydro-sedimentary transformation since the 1950s, with several tributary koris shifting from a historically endorheic, or closed, drainage regime to an exorheic one in which they now discharge directly into the Niger River, delivering substantial sediment loads in the process (Leblanc et al., 2008). This transition has been linked to the progressive widening and deepening of gully channels in response to increased runoff generation on cleared and crusted upslope surfaces, with consequent bank erosion and the formation of large alluvial fans at kori confluences with the Niger River, in places measurably altering the river's own bed morphology and flow characteristics. The rate of gully extension has itself been treated as a diagnostic indicator of upstream land degradation intensity, since the density and length of gully networks respond directly to the volume and concentration of overland flow generated by crusted, poorly vegetated catchments.

5.3 River Sediment Dynamics and the Niger River

Sediment delivered from the eroding koris and glacis of southwestern Niger contributes to the wider siltation and alluvial fan development observed along the middle Niger River in the Niamey reach, a process attributed substantially to the same land use changes that have driven the hydrological transformations described above, rather than to climatic factors alone. This river-scale sedimentary response illustrates that the consequences of localised soil erosion in southwestern Niger extend beyond the immediate agricultural landscape to affect the geomorphology and sediment budget of a river of continental significance.

6. Impacts on Agricultural Productivity and Rural Livelihoods

6.1 Direct Crop Damage from Wind Erosion

Wind erosion inflicts direct, visible damage on Sahelian pearl millet cultivation through the physical burial and abrasion of young seedlings during sand-laden storms that typically occur at the start of the rainy season, before crop canopy cover has developed sufficiently to protect the soil surface. Monitoring at the ICRISAT Sahelian Centre found that a substantial proportion of millet sowing pockets, in some seasons approaching ninety per cent, could be entirely covered by wind-transported sand within the first three weeks after emergence, necessitating resowing and imposing a direct labour and yield cost on farming households (Michels et al., 1993). Even where seedlings survive partial burial, documented delays in subsequent growth and development translate into reduced final grain yield, compounding the nutrient losses associated with the erosive process itself.

6.2 Soil Fertility Decline and Nutrient Export

Because both wind and water erosion selectively remove the finest, most nutrient- and organic-matter-rich soil fractions, their cumulative effect on already inherently infertile Sahelian sandy soils is a progressive decline in the capacity of fields to sustain crop yields without external nutrient inputs. This dynamic underlies the farmer perception, recorded in ethnographic work at Fandou Béri, that loss of soil fertility rather than loss of soil mass is the more pressing practical concern, since fertility decline manifests directly and immediately in reduced harvests, whereas gross soil loss may not be perceptible to farmers over a single season (Warren et al., 2001). The agroforestry literature provides a complementary perspective on fertility maintenance, with field trials demonstrating that millet grown beneath Faidherbia albida canopies achieves markedly higher biomass than millet grown in adjacent open fields, an effect attributed to enhanced soil nitrogen and phosphorus availability beneath the canopy together with more favourable microclimate, underscoring the productivity value of the parkland trees whose loss through dieback or clearance has been separately documented to depress yields substantially (Kho et al., 2001; Tougiani et al., 2021).

6.3 Socio-economic Dimensions and the Political Ecology of Erosion

A recurring theme in the southwestern Niger literature, most explicitly articulated through the "local political ecology" framework, is that biophysical erosion rates alone are an incomplete guide to the social significance of land degradation, since farmers' land use decisions are embedded within broader livelihood strategies encompassing off-farm income, labour allocation, ethnic identity and land tenure arrangements (Warren et al., 2001). Correlational evidence linking erosion severity to patterns of male labour migration has been interpreted as indicating that households with access to non-farm income may adopt a form of risk-avoidance in which soil conservation investment is deprioritised relative to other livelihood strategies, a finding with direct implications for the design of erosion control interventions that assume farmers will invest labour in soil conservation purely on the basis of biophysical erosion risk (Warren et al., 2001). This body of work cautions against interventions premised solely on measured erosion rates, and argues for policy approaches that engage with the social and economic logics underlying observed land management decisions.

7. Soil and Water Conservation Responses

7.1 Indigenous and Mechanical Water Harvesting

A range of indigenous water-harvesting structures, most prominently zaï, known in Niger as tassa, together with half-moons and stone bunds, form the core of soil and water conservation practice across the region. These techniques share a common principle: farmers dig or shape small basins or crescents that concentrate scarce rainfall and runoff around the planting point, typically enriched with manure or compost, thereby addressing simultaneously the infiltration deficit created by surface crusting and the nutrient depletion associated with continuous cultivation. A recent continent-wide synthesis of soil and water conservation practice in Africa identifies such in situ water-harvesting structures, alongside conservation agriculture, agroforestry and integrated soil fertility management, as among the most consistently promising options for restoring degraded cropland productivity in semi-arid environments, while cautioning that their effectiveness depends strongly on complementary organic or mineral nutrient inputs rather than water-harvesting structure alone (Diop et al., 2022). Econometric analysis of adoption behaviour among Nigerien farming households found that adoption and intensity of use of tassa and related half-crescent earthen structures was positively associated with the proportion of degraded farmland on a holding and with lower farmer risk aversion, but was not significantly related to farmer age, indicating that targeting of conservation programmes toward the most degraded parcels, together with sustained extension support, is likely to be more effective than age-based targeting strategies (Baidu-Forson, 1999).

7.2 Half-moons and Mechanical Soil and Water Conservation Structures

Half-moon structures, semi-circular earthen bunds that capture and concentrate rainfall runoff around planted seedlings or crop rows, have been deployed at substantial scale across the Sahel, including through internationally financed rehabilitation programmes implemented by the World Food Programme with support from the United States Agency for International Development. Remote sensing evaluation of eighteen such intervention sites in southern Niger, using Landsat vegetative greenness observations, found measurable increases in vegetation cover attributable to the half-moon interventions relative to untreated comparison areas, supporting the technique's role in restoring productive capacity to degraded land at farm scale (Mishra et al., 2023). A more recent Bayesian growth-modelling evaluation of tree establishment across several soil and water conservation structures in Niger, including half-moons, trenches, bench terraces and stone bunds, found that half-moons produced the greatest enhancement of tree growth among the structures tested, and that geomorphological position, with pediments outperforming plateaux and slopes, exerted an additional strong influence on restoration outcomes (Wourro et al., 2026).

7.3 Agroforestry and Farmer-Managed Natural Regeneration

Beyond engineered water-harvesting structures, agroforestry parklands built around scattered Faidherbia albida trees represent a longstanding indigenous soil fertility management strategy in southwestern Niger, exploiting the species' reverse phenology, in which leaf shedding coincides with the cropping season, to minimise competition with associated cereals while contributing nitrogen-rich litter and improved microclimate beneath the canopy (Kho et al., 2001). More broadly across the Sahel, farmer-managed natural regeneration, in which farmers protect and manage the natural regrowth of woody stumps and root systems within cultivated fields rather than relying solely on planting, has been identified as a low-cost restoration pathway, although a review of its drivers across multiple Sahelian countries found that the presence of desired tree species in the vicinity and protection of regenerating stems from grazing were preconditions for successful outcomes, implying that natural regeneration alone will be insufficient in landscapes where seed sources or grazing pressure preclude spontaneous recovery (Lohbeck et al., 2020).

7.4 Adaptive Combination of Practices under Climate Variability

A meta-analytic and modelling study conducted in southwestern Niger, combining a review of case studies with field survey data and simulation using the AquaCrop model, found that the combined practice of zaï pits together with organic mulch produced crop yields up to twice those of unamended control plots under a high-emission climate scenario, and concluded that this combined practice offered the most promising prospects among those examined for reversing soil degradation and sustaining productivity under projected future warming and rainfall decline (Issoufou et al., 2020). This finding illustrates a broader pattern in the conservation literature, namely that combinations of water-harvesting structure with organic or mineral soil amendment consistently outperform either measure applied in isolation, since water-harvesting structures address the runoff and infiltration deficit associated with crusting while organic amendments address the parallel nutrient depletion associated with both erosion and continuous cultivation without fallow. Table 3 summarises the principal conservation techniques evaluated in the region.

Table 3. Selected soil and water conservation techniques evaluated in southwestern Niger

Technique	Principal mechanism	Reported outcome	Source
In situ water harvesting (zaï/tassa, half-moons, stone bunds)	Concentrated capture of runoff and organic matter at the planting point	Identified as among the most promising options for restoring degraded cropland productivity in semi-arid Africa, contingent on complementary nutrient inputs	Diop et al. (2022)
Zaï combined with organic mulch	Combined water harvesting and nutrient amendment	Crop yield up to twice that of control plots under high-emission climate projection	Issoufou et al. (2020)
Half-moon structures	Semi-circular bunds concentrating runoff around plants	Half-moons the most effective structure for enhancing tree growth among five techniques tested	Wourro et al. (2026)
Half-moon rehabilitation at farm scale	Water and soil retention for vegetation establishment	Measurable vegetation greenness increase across 18 monitored sites in southern Niger	Mishra et al. (2023)
Faidherbia albida parklands	Nitrogen-fixing canopy trees with reverse phenology	Millet biomass substantially higher beneath canopy than in open field	Kho et al. (2001)
Farmer-managed natural regeneration	Protected regrowth of woody stumps in cultivated fields	Success contingent on nearby seed sources and protection from grazing	Lohbeck et al. (2020)

8. Climate Variability, Vegetation Trends and the Re-greening Debate

8.1 The regional Greening Signal

A substantial body of satellite-based research using the Normalized Difference Vegetation Index has documented a broad increase in Sahelian vegetation greenness since the mid-1980s, interpreted by several authors as a partial recovery from the severe droughts of the preceding two decades and as evidence against earlier narratives of irreversible, unidirectional desertification across the region (Herrmann et al., 2005). This greening trend has been shown to be driven predominantly by the recovery of rainfall following the drought period, although the residual variance not explained by rainfall alone has been attributed in part to human-induced land management changes superimposed on the underlying climatic signal (Herrmann et al., 2005).

8.2 Local Degradation Beneath a Regional Greening Trend

Notwithstanding this regional pattern, site-level and sub-regional analyses focused on southwestern Niger have consistently identified areas of continued or accelerating degradation that are masked when vegetation trends are examined only at coarse regional resolution. Analysis bridging vegetation trend detection with land use and land cover change data, focused specifically on the Degré Carré de Niamey site, found that while approximately sixteen per cent of the wider Sahel showed a re-greening signal over the period from 2000 to 2015, a smaller but locally significant proportion showed degradation attributable chiefly to factors other than rainfall, underscoring the spatial heterogeneity that a purely regional greening narrative obscures (Leroux et al., 2017). Complementary work on the tiger bush plateaux of South West Niger similarly found a persistent decline in banded woody vegetation over the same period during which regional rainfall had recovered, a pattern inconsistent with the expectation that vegetation recovery should track the rainfall trend, and instead pointing to anthropogenic disturbance as the dominant local driver (Fiorillo et al., 2017). Likewise, the tiger bush fragmentation documented over the 1960 to 1992 period at Hamdallaye occurred despite historical climatic conditions that would not, on rainfall grounds alone, have predicted such a marked structural decline in woody cover, reinforcing the conclusion that human disturbance rather than climate has been the principal proximate driver of degradation at this particular landscape unit (Wu et al., 2000).

8.3 Reconciling Greening and Degradation Narratives

The apparent contradiction between regional greening and local degradation narratives is most plausibly reconciled by recognising that vegetation indices at coarse spatial resolution are dominated by herbaceous and shrub biomass responses to interannual rainfall variability, which recover rapidly once rainfall improves, whereas the loss of structurally important woody vegetation, altered soil surface hydrological properties and gully network development represent slower, less readily reversible forms of degradation that persist even where herbaceous biomass has recovered. This distinction has direct relevance for land restoration policy, since interventions premised on regional greening trends risk overlooking the persistence of structural, hydrological and soil physical degradation at the farm and landscape scale that continues to constrain agricultural productivity in southwestern Niger specifically. Table 4 sets out the evidence underlying this paradox.

Table 4. Evidence on the greening–degradation paradox in southwestern Niger

Spatial scale	Observed vegetation trend, 2000–2015 (approximate)	Interpretation	Source
Regional Sahel (1982–2003)	Widespread increase in monthly maximum NDVI, associated chiefly with rainfall recovery	Partial recovery from prior drought; residual variance suggests some anthropogenic contribution	Herrmann et al. (2005)
Western Sahel and Degré Carré de Niamey	Approximately 16 per cent re-greening regionally; localised decrease attributable chiefly to non-rainfall factors	Land use and land cover change contribute independently of rainfall to observed vegetation trends	Leroux et al. (2017)
Tiger bush plateau, South West Niger	Persistent decline in woody banded vegetation and NDVI, 2000–2015	Continued anthropogenic clearance despite regional rainfall recovery	Fiorillo et al. (2017)
Tiger bush landscape, Hamdallaye	Marked fragmentation of banded vegetation, 1960–1992	Grazing and fuelwood harvest identified as dominant drivers, independent of rainfall trend	Wu et al. (2000)

9. Governance, Adoption and Institutional Dimensions

9.1 Adoption Determinants for Conservation Technologies

Empirical analysis of the determinants of adoption of land-enhancing conservation technologies among Nigerien farming households has identified the proportion of degraded farmland on a holding and lower farmer risk aversion as significant positive predictors of adoption intensity for tassa and half-crescent earthen structures, while farmer age was found not to be significantly associated with adoption, a finding with practical implications for extension targeting strategies that might otherwise assume younger farmers are more receptive to innovation (Baidu-Forson, 1999). These results support a policy emphasis on targeting conservation programmes toward the most severely degraded parcels within a landscape, where the productivity returns to investment are likely to be greatest and most visible to farmers, together with sustained investment in extension services that reduce farmers' perceived risk of technology failure.

9.2 The Local Political Ecology of Erosion Response

The local political ecology framework developed from research in southwestern Niger argues explicitly that policies addressing soil erosion cannot rely solely on biophysical erosion data or generalised notions of natural or social causation, since the social context governing land management decisions in the Sahel is highly variable across both space and time (Warren et al., 2001). This perspective cautions against uniform, top-down conservation policies and instead calls for approaches grounded in locally specific understanding of how farming households accommodate, tolerate or actively resist erosion within their broader livelihood strategies, a call that retains relevance for the design of contemporary large-scale land restoration programmes.

9.3 Large-scale Restoration Initiatives and Their Institutional Context

Niger's engagement with international land restoration commitments, including pledges made in connection with the fifteenth Conference of the Parties to the United Nations Convention to Combat Desertification to restore substantial areas of degraded land and to achieve land degradation neutrality, has translated into a marked expansion of mechanical and biological soil and water conservation works implemented at the farm and landscape scale, including the half-moon and stone bund structures whose performance has been evaluated in the studies reviewed above (Wourro et al., 2026). Table 5 summarises the principal institutional and socio-economic factors identified as shaping conservation outcomes in the region.

Table 5. Institutional and socio-economic factors influencing soil and water conservation outcomes in southwestern Niger

Factor	Documented relationship to conservation outcomes	Source
Proportion of degraded farmland on a holding	Positively associated with adoption and intensity of use of tassa and half-crescent structures	Baidu-Forson (1999)
Farmer risk aversion	Lower risk aversion positively associated with adoption intensity	Baidu-Forson (1999)
Farmer age	Not significantly associated with adoption	Baidu-Forson (1999)
Geomorphological position of restoration structure	Pediments produce better tree growth outcomes than plateaux or slopes	Wourro et al. (2026)
Household access to non-farm income and labour migration	Associated with reduced investment in soil conservation, interpreted as a risk-avoidance strategy	Warren et al. (2001)

10. Future Directions

Several priorities emerge from this synthesis for future research and intervention design in southwestern Niger. There is a continuing need to reconcile coarse-resolution regional vegetation monitoring with fine-scale, ground-validated assessment of structural and hydrological degradation, since reliance on regional greening trends alone risks masking persistent farm- and landscape-scale erosion that constrains local livelihoods. Longer time series combining high-resolution optical and radar remote sensing with targeted ground monitoring of gully extension, crusting incidence and woody cover would help close this gap. The demonstrated superiority of combined interventions, such as zaï pits with organic mulch, over single-measure approaches suggests that future conservation programming should be designed and evaluated as integrated packages rather than as isolated technologies, with particular attention to the sequencing of water-harvesting structures, organic amendment and woody cover restoration under a changing climate. Given the consistent finding that groundwater recharge in the region has been shaped substantially by land use change rather than rainfall alone, closer integration of hydrogeological monitoring with land management planning is warranted, so that the benefits of increased recharge can be captured for irrigation development without exacerbating the gully erosion that generates it. Adoption research indicates that targeting of restoration investment toward the most degraded parcels, combined with sustained extension support, is likely to yield greater returns than uniform area-based targeting, a principle that could usefully inform the spatial allocation of future donor-financed restoration programmes. Finally, the emerging evidence that grazed rangeland can be more erodible than adjacent cropland warrants closer research and policy attention to grazing management, alongside the longer-established focus on cropland conservation, if wind erosion control strategies are to address the full range of land uses contributing to sediment flux in the region. Closer attention to the socio-economic and migration dynamics identified within the local political ecology literature, including the relationship between off-farm income, labour allocation and conservation investment, would strengthen the design of interventions intended to secure durable farmer engagement rather than short-term, externally driven adoption.

11. Conclusions

Soil erosion in southwestern Niger reflects the interaction of an inherently erosion-prone biophysical environment, comprising sandy, crust-prone soils under a highly seasonal and variable rainfall regime, with a demographic and land use trajectory that has substantially intensified erosive processes since the mid-twentieth century. Wind erosion remains a dominant threat to cultivated fields during the early rainy season, capable of burying and damaging crops directly in addition to stripping nutrient-rich soil fractions, while water erosion, driven by surface crusting, generates runoff that both reduces crop-available water and has, cumulatively across the landscape, produced substantial increases in groundwater recharge and river sediment delivery over recent decades. These processes are not uniformly distributed but are concentrated at the interface of expanding cultivation, retreating fallow and woodland, and intensifying grazing and fuelwood extraction, with degradation of the region's characteristic tiger bush plateaux serving as a particularly clear indicator of this anthropogenic intensification, and with recent evidence that grazed rangeland can itself be more erosion-prone than cultivated land. A regional trend of vegetation greening since the 1980s, driven substantially by rainfall recovery, coexists with continued or accelerating local degradation in southwestern Niger specifically, a paradox that underscores the limitations of relying on coarse-scale vegetation monitoring alone to assess land condition. Indigenous and introduced soil and water conservation techniques, including zaï and tassa pits, half-moon structures and Faidherbia albida-based agroforestry, have demonstrated substantial capacity to reduce erosion and restore productivity where properly targeted, particularly when combined with organic soil amendment, although their durable adoption depends on socio-economic factors including access to extension services, degradation severity and farmers' broader livelihood strategies rather than on biophysical erosion risk alone.

12. Limitations

This review is subject to several limitations inherent in its narrative rather than systematic design. The absence of a fixed, quantitatively pooled effect-size analysis means that the relative magnitude of different erosion drivers and conservation interventions cannot be compared with statistical precision across studies, and the synthesis instead relies on qualitative integration of findings drawn from methodologically heterogeneous studies conducted at different sites, spatial scales and time periods. The literature reviewed is concentrated at a relatively small number of intensively monitored research sites, including Banizoumbou, Wankama, Sadoré, Hamdallaye and Fandou Béri, raising the possibility that findings from these locations may not generalise fully to the wider southwestern Niger region, particularly to areas outside the immediate hinterland of Niamey that have received comparatively less research attention. The exclusion of grey literature, theses, conference proceedings and francophone sources not available in indexed peer-reviewed journals may have omitted locally significant findings, particularly from national Nigerien research institutions and development project evaluations that are not consistently indexed in the international databases searched; several original technique-specific descriptions of zaï and tassa performance, for instance, exist primarily in French-language geography and development literature that fell outside this review's citation criteria and could not be independently verified for inclusion. Finally, the rapidly evolving character of both the remote sensing and hydrological modelling literatures means that the most recent findings, particularly those emerging after the close of the present search window, may refine or revise some of the conclusions drawn here, underscoring the need for periodic updating of this synthesis as the evidence base continues to develop.

Declaration of AI Use

This manuscript was prepared through the combined contributions of all author(s), including contributions to the study design, data, content development, results, interpretation, and related scholarly work. The author(s) acknowledge the use of Grammarly and ChatGPT to assist with grammar checking, language refinement, reference formatting. These AI-assisted tools were not used as authors and did not replace the intellectual contributions or scholarly judgment of the author(s). All AI-assisted outputs, including content, references, and interpretations, were carefully reviewed, revised, verified, and approved by the author(s). The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Abdourhamane Touré, A., Rajot, J.-L., Garba, Z., Marticorena, B., Petit, C., & Sebag, D. (2011). Impact of very low crop residues cover on wind erosion in the Sahel. *Catena, 85*(3), 205–214. https://doi.org/10.1016/j.catena.2011.01.002

Baidu-Forson, J. (1999). Factors influencing adoption of land-enhancing technology in the Sahel: Lessons from a case study in Niger. *Agricultural Economics, 20*(3), 231–239. https://doi.org/10.1016/S0169-5150(99)00009-2

Bielders, C. L., Michels, K., & Rajot, J.-L. (2000). On-farm evaluation of ridging and residue management practices to reduce wind erosion in Niger. *Soil Science Society of America Journal, 64*(5), 1776–1785. https://doi.org/10.2136/sssaj2000.6451776x

Chappell, A., Warren, A., Taylor, N., & Charlton, M. (1998). Soil flux (loss and gain) in southwestern Niger and its agricultural impact. *Land Degradation & Development, 9*(4), 295–310. https://doi.org/10.1002/(SICI)1099-145X(199807/08)9:4<295::AID-LDR293>3.0.CO;2-J

Diop, M., Chirinda, N., Beniaich, A., El Gharous, M., & El Mejahed, K. (2022). Soil and water conservation in Africa: State of play and potential role in tackling soil degradation and building soil health in agricultural lands. *Sustainability, 14*(20), 13425. https://doi.org/10.3390/su142013425

Fiorillo, E., Maselli, F., Tarchiani, V., & Vignaroli, P. (2017). Analysis of land degradation processes on a tiger bush plateau in southwest Niger using MODIS and LANDSAT TM/ETM+ data. *International Journal of Applied Earth Observation and Geoinformation, 62*, 56–68. https://doi.org/10.1016/j.jag.2017.05.010

Greenhalgh, T., Thorne, S., & Malterud, K. (2018). Time to challenge the spurious hierarchy of systematic over narrative reviews? *European Journal of Clinical Investigation, 48*(6), e12931. https://doi.org/10.1111/eci.12931

Herrmann, S. M., Anyamba, A., & Tucker, C. J. (2005). Recent trends in vegetation dynamics in the African Sahel and their relationship to climate. *Global Environmental Change, 15*(4), 394–404. https://doi.org/10.1016/j.gloenvcha.2005.08.004

Hiernaux, P., Adamou, K., Kergoat, L., Brandt, M., Mougin, E., & Fitts, Y. (2022). Woody plant decline in the Sahel of western Niger (1996–2017): Is it driven by climate or land use changes? *Journal of Arid Environments, 200*, 104719. https://doi.org/10.1016/j.jaridenv.2022.104719

Ibrahim, M., Favreau, G., Scanlon, B. R., Seidel, J.-L., Le Coz, M., Demarty, J., & Cappelaere, B. (2014). Long-term increase in diffuse groundwater recharge following expansion of rainfed cultivation in the Sahel, West Africa. *Hydrogeology Journal, 22*(6), 1293–1305. https://doi.org/10.1007/s10040-014-1143-z

Ide, I., Abdourhamane Touré, A., Rajot, J.-L., Marticorena, B., Noma Adamou, S., Pierre, C., Hassane, B., & Garba, Z. (2025). Wind erosion dynamics associated with land use on sandy soils under heavy anthropogenic pressure (southwestern Niger). *Land Degradation & Development, 36*(16), 5772–5785. https://doi.org/10.1002/ldr.70037

Issoufou, A. A., Soumana, I., Maman, G., Konaté, S., & Mahamane, A. (2020). Dynamic relationship of traditional soil restoration practices and climate change adaptation in semi-arid Niger. *Heliyon, 6*(1), e03265. https://doi.org/10.1016/j.heliyon.2020.e03265

Kho, R. M., Yacouba, B., Yayé, M., Katkoré, B., Moussa, A., Iktam, A., & Mayaki, A. (2001). Separating the effects of trees on crops: The case of *Faidherbia albida* and millet in Niger. *Agroforestry Systems, 52*(3), 219–238. https://doi.org/10.1023/A:1011820412140

Le Coz, M., Favreau, G., & Ousmane, S. D. (2013). Modeling increased groundwater recharge due to change from rainfed to irrigated cropping in a semiarid region. *Vadose Zone Journal, 12*(2). https://doi.org/10.2136/vzj2012.0148

Leblanc, M. J., Favreau, G., Massuel, S., Tweed, S. O., Loireau, M., & Cappelaere, B. (2008). Land clearance and hydrological change in the Sahel: SW Niger. *Global and Planetary Change, 61*(3–4), 135–150. https://doi.org/10.1016/j.gloplacha.2007.08.011

Leroux, L., Bégué, A., Lo Seen, D., Jolivot, A., & Kayitakire, F. (2017). Driving forces of recent vegetation changes in the Sahel: Lessons learned from regional and local level analyses. *Remote Sensing of Environment, 191*, 38–54. https://doi.org/10.1016/j.rse.2017.01.014

Lohbeck, M., Albers, P., Boels, L. E., Bongers, F., Morel, S., Sinclair, F., Takoutsing, B., Vågen, T.-G., Winowiecki, L. A., & Smith-Dumont, E. (2020). Drivers of farmer-managed natural regeneration in the Sahel: Lessons for restoration. *Scientific Reports, 10*, 15038. https://doi.org/10.1038/s41598-020-70746-z

Michels, K., Sivakumar, M. V. K., & Allison, B. E. (1993). Wind erosion in the southern Sahelian zone and induced constraints to pearl millet production. *Agricultural and Forest Meteorology, 67*(1–2), 65–77. https://doi.org/10.1016/0168-1923(93)90050-R

Mishra, V., Limaye, A. S., Doehnert, F., Policastro, R., Hassan, D., Ndiaye, M. T. Y., Van Abel, N., Johnson, K., Grange, J., Coffey, K., & Rashid, A. (2023). Assessing impact of agroecological interventions in Niger through remotely sensed changes in vegetation. *Scientific Reports, 13*, 360. https://doi.org/10.1038/s41598-022-27242-3

Nishigaki, T., Ikazaki, K., Shinjo, H., Tanaka, U., Fatondji, D., & Funakawa, S. (2025). Pearl millet yield reduction by soil erosion and its recovery potential through fertilizer application on an Arenosol in the Sahel. *Soil and Tillage Research, 246*, 106324. https://doi.org/10.1016/j.still.2024.106324

Pierre, C., Hiernaux, P., Rajot, J.-L., Kergoat, L., Webb, N. P., Abdourhamane Touré, A., Marticorena, B., & Bouet, C. (2022). Wind erosion response to past and future agro-pastoral trajectories in the Sahel (Niger). *Landscape Ecology, 37*(2), 529–550. https://doi.org/10.1007/s10980-021-01359-8

Sadda, A.-S., Loireau, M., Jangorzo, N. S., Issoufou, H. B.-A., & Chotte, J.-L. (2023). Standardized description of degraded land reclamation actions and mapping of actors' roles: A key step for action in combatting desertification (Niger). *Land, 12*(5), 1064. https://doi.org/10.3390/land12051064

Tougiani, A., Massaoudou, M., Haougui, A., Laouali, A., & Weber, J. C. (2021). *Faidherbia albida* (Delile) tree dieback effects on crop production in the parkland agroforests of southwestern Niger. *International Journal of Forestry Research, 2021*, Article 8895829. https://doi.org/10.1155/2021/8895829

Warren, A., Batterbury, S., & Osbahr, H. (2001). Soil erosion in the West African Sahel: A review and an application of a "local political ecology" approach in southwest Niger. *Global Environmental Change, 11*(1), 79–95. https://doi.org/10.1016/S0959-3780(00)00047-9

Warren, A., Osbahr, H., Batterbury, S., & Chappell, A. (2003). Indigenous views of soil erosion at Fandou Béri, southwestern Niger. *Geoderma, 111*(3–4), 439–456. https://doi.org/10.1016/S0016-7061(02)00276-8

Wourro, F., Akodewou, A., Kassi N'dja, J., & Hérault, B. (2026). Re-greening the Sahel? Evaluating tree cover restoration strategies in Niger. *Journal of Arid Environments, 232*, 105484. https://doi.org/10.1016/j.jaridenv.2025.105484

Wu, X. B., Thurow, T. L., & Whisenant, S. G. (2000). Fragmentation and changes in hydrologic function of tiger bush landscapes, southwest Niger. *Journal of Ecology, 88*(5), 790–800. https://doi.org/10.1046/j.1365-2745.2000.00491.x

Zeng, Y., Jia, L., Jiang, M., Zheng, C., Menenti, M., Bennour, A., & Lv, Y. (2024). Hydrological factor and land use/land cover change explain the vegetation browning in the Dosso Reserve, Niger. *Remote Sensing, 16*(10), 1728. https://doi.org/10.3390/rs16101728

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