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Optimal Cover Crops for Land Reclamation in West Africa: A Review of Performance, Adaptability, and Ecosystem Benefits

Priscilla Badaweh Coffie [a*], Richard Amankwah Kuffour [b], Kwadwo Gyasi Santo [c], Michael Asigbaase [d], Ophelia Ayamba [e] and Sampson Owusu [f]

[a] Department of Land Management, University of Energy and Natural Resources, Sunyani, Ghana.
[b] Department of Environmental Health and Sanitation Education, Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development, Mampong Ashanti, Ghana.
[c] Department of Horticulture and Crop Production, University of Energy and Natural Resources, Sunyani, Ghana.
[d] Department of Forest Science, University of Energy and Natural Resources, Sunyani, Ghana.
[e] Department of Sustainable Minerals and Resource Development, University of Energy and Natural Resources, Sunyani, Ghana.
[f] Soil Genesis and Classification Division, CSIR - Soil Research Institute, Kumasi, Ghana.

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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**Corresponding author: E-mail: badawehcoffiepriscilla@gmail.com;*

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Abstract

Land degradation is a major problem in West Africa and is driven by soil erosion, nutrient depletion, mining activities, deforestation, and climate variability. Cover crops are increasingly promoted as low-cost, nature-based tools for reclaiming degraded land, but their success depends on matching plant traits to local soil conditions, climate, and land-use history. This review assesses the performance and suitability of cover crops for land restoration across West Africa, with emphasis on functional traits, environmental adaptation, and ecosystem services under different degradation scenarios. A narrative review approach was applied to published field studies, on-farm trials, and land-rehabilitation projects from the defined search period, retrieved from major academic databases and regional grey literature. Studies were grouped by functional types, including legumes, grasses, and non-leguminous broadleaf species. Outcomes were synthesised for erosion control, soil organic-matter recovery, nutrient cycling, biological activity, crop establishment, and management limitations. The reviewed literature consistently reports reductions in runoff and soil loss, increases in organic inputs, and improved nutrient availability following cover-crop use. Legumes enhanced soil nitrogen through biological fixation, while grasses stabilised soil structure through dense root systems and persistent ground cover. Mixed plantings often showed greater stability under variable rainfall because complementary rooting depth and canopy structure improved water capture and reduced nutrient losses. However, performance varied with soil type, rainfall regime, degradation severity, and management practices. Different reclamation contexts require tailored strategies. Post-mining lands benefit from stress-tolerant pioneer species before productive legumes are introduced. Severely eroded fields require fast-establishing species with extensive roots, while dry savanna and Sahelian zones require drought-tolerant, short-season crops. Cover crops are an effective and adaptable option for land restoration in West Africa, but no single species suits all conditions. Policy programmes should prioritise site-specific selection, promote legume–grass mixtures, integrate extension services, and support long-term field trials in vulnerable landscapes.

Keywords: *Cover crops; land reclamation; soil fertility; nitrogen fixation; ecosystem services; West Africa.*

1. Introduction

Land degradation and declining soil fertility are among the most pressing environmental and agricultural challenges in West Africa (Alves et al., 2020). It results from poor land-use practices, deforestation, overgrazing, and changing climate patterns. Illegal mining activities, known locally as galamsey, have also worsened the situation (Herrmann et al., 2020). These mining practices destroy vegetation, pollute water bodies, and leave the land bare and unproductive. They also release heavy metals like mercury and arsenic into soil and water. Such disturbances reduce soil fertility, damage biological productivity, and weaken the health of ecosystems (Rodenburg et al., 2021). Declining soil quality leads to reduced crop yields and increased food insecurity. Many rural communities that rely on agriculture are now more vulnerable. Reversing this degradation is necessary to protect livelihoods and ensure long-term sustainability. One possible solution is the use of cover crops for land reclamation (Di Bene et al., 2022).

Cover crops are plants grown not for harvest but to improve soil health and protect land from degradation. Common examples include legumes like *Mucuna pruriens*, *Crotalaria juncea*, and *Sesbania rostrata*, which have been used in West Africa (Blomme et al., 2022, Mulinge et al., 2017). Globally, *Vicia villosa* (hairy vetch) in Europe (Renzi et al., 2020) and *Avena sativa* (oats) in North America have improved soil nitrogen and organic content significantly (Lu et al., 2025). In Brazil, *Crotalaria spectabilis* has shown promise in rehabilitating degraded tropical soils (Das Chagas et al., 2024). Such evidence supports the use of cover crops for effective land reclamation worldwide. Cover crops help maintain key soil components critical to land productivity (Ariom et al., 2022, Ofoezie et al., 2022, Sagna et al., 2021). They improve soil organic matter, which supports microbial activity and nutrient cycling. These crops also stabilize soil structure, which improves water retention and reduces compaction (Mechiche-Alami and Abdi, 2020). Through nitrogen fixation, legumes enrich soil fertility naturally without chemical inputs. Cover crops suppress weed growth and reduce surface runoff, limiting soil erosion (Nord et al., 2022). Some species absorb toxic elements such as cadmium and zinc, helping detoxify contaminated soils. Together, these functions preserve essential soil properties and improve conditions for future crop production (Ziadat et al., 2022). Evidence shows that species such as *Mucuna pruriens*, *Crotalaria* spp., and *Stylosanthes* spp. can increase soil organic carbon (SOC), enhance nutrient cycling, and reduce erosion (Obiero et al., 2023, Obiero et al., 2023, Takyi et al., 2021). Long-term *Mucuna* trials in Senegal recorded SOC gains of over 4 Mg C/ha after eight years. Ghanaian studies found maize yield gains of over 1.2 t/ha with cover crop use. Cover crops also deliver important ecosystem services. They reduce greenhouse gas emissions by improving nitrogen-use efficiency and lowering N_2O and CH_4 emissions (Basche et al., 2014). They protect soil from erosion, reducing sediment loss by up to 70%. Water infiltration and retention also improve, increasing resilience against drought. Agronomically, they suppress weeds such as *Striga hermonthica* and disrupt pest and disease cycles. They also provide high-quality livestock fodder during dry seasons (Teasdale et al., 2007). Economic studies report returns on investment exceeding 200% in multi-year adoption cases (Boucher et al., 2021).

Despite growing interest, many studies are small and localized. This makes it difficult to compare results or create regional recommendations. There is little combined data showing which cover crops work best in different West African environments. The region has many types of soil and farming systems. This makes it important to find the right species for each setting. A systematic review can help bring together the available research. It will help identify effective species and practices that restore degraded land. This review aims to evaluate cover crop species used for land reclamation in West Africa.

2. Conceptual Framework: Defining “Optimal” Cover Crops for Land Reclamation

In this review, optimal cover crops are defined as those that effectively support land reclamation under the environmental and socioeconomic conditions of West Africa. Optimality is not uniform across locations but depends on the type and severity of land degradation, local climate, soil characteristics, and the specific goals of reclamation (Liu et al., 2020). This framework, therefore, emphasises how cover crops function within degraded systems rather than ranking individual species (Kumar et al., 2020) illustrated in Figure 1. Land degradation in West Africa occurs in several forms, including post-mining lands, severely eroded soils, and long-term nutrient-depleted agricultural fields. Each context presents different limitations and recovery priorities (Islam and Sherman, 2021, Quintarelli et al., 2022). On severely degraded sites, rapid ground cover and soil stabilisation are often the primary needs. In contrast, on chronically degraded croplands, improving soil fertility, organic matter, and biological activity becomes more important. A cover crop is considered optimal when it directly addresses the most limiting constraint at a given site. The framework places strong emphasis on functional traits of cover crops (Lambe et al., 2020).

Traits such as rapid germination, early canopy development, rooting depth and density, biological nitrogen fixation, biomass production, and tolerance to drought or low soil fertility largely determine reclamation performance (Quintarelli et al., 2022, Lambe et al., 2020, Kik et al., 2021). Rather than asking which species performs best in general, this approach focuses on which traits are best suited to local conditions and intended restoration outcomes. Optimality is assessed using measurable performance outcomes. These include establishment success, improvements in soil physical properties such as structure and infiltration, increases in soil organic carbon and nutrient availability, reductions in runoff and erosion, and enhancement of soil biological activity (Gao et al., 2021). In some situations, additional benefits such as fodder production or mulch provision are also relevant. Because no single cover crop can maximise all outcomes at once, optimal choices involve balancing trade-offs in line with site priorities. Management practices are a central component of this framework (Lamichhane and Alletto, 2022). Factors such as planting time, seeding rate, nutrient inputs, termination method, and grazing pressure can strongly influence cover crop performance. A cover crop is therefore considered optimal only when it performs well under realistic local management conditions (Tsakiridis et al., 2023). Socioeconomic considerations including seed availability, labour demands, cost, and compatibility with existing farming systems, further determine whether a cover crop can be adopted and sustained (Hoang, 2021).

3. Methods

3.1 Review Design

This study adopted a structured narrative review approach with systematic elements to examine cover crops used for land reclamation in West Africa. The review was designed to collect, organize, and synthesize evidence from diverse study types, including field experiments, on-farm trials, and applied reclamation projects. A narrative–systematic approach was selected because studies in this field often differ in design, duration, and outcome measures, making formal meta-analysis difficult. This approach allowed the integration of agronomic, ecological, and socioeconomic evidence in a transparent and reproducible manner (Turnbull et al., 2023).

3.2 Definition of Key Concepts

Clear operational definitions were applied to ensure consistency across studies. Land reclamation was defined as the improvement of degraded or disturbed land to restore basic soil function, vegetation cover, and ecosystem services. Cover crops were defined as plant species grown primarily to protect, improve, or rehabilitate soil rather than for direct harvest. Optimal cover crops were considered those that showed good establishment, adaptability to local conditions, measurable soil and ecosystem benefits, and practical feasibility for use in West African reclamation settings (Grant and Booth, 2009).

3.3 Geographical Scope of the Review

The review focused on West Africa, including countries within the region where land degradation and soil fertility decline are major challenges. Studies conducted within these countries were prioritised. However, studies from other tropical or semi-arid regions were also considered if they addressed similar climatic conditions, soil constraints, and reclamation objectives relevant to West Africa. This approach helped to strengthen the evidence base where regional data were limited (Turnbull et al., 2023).

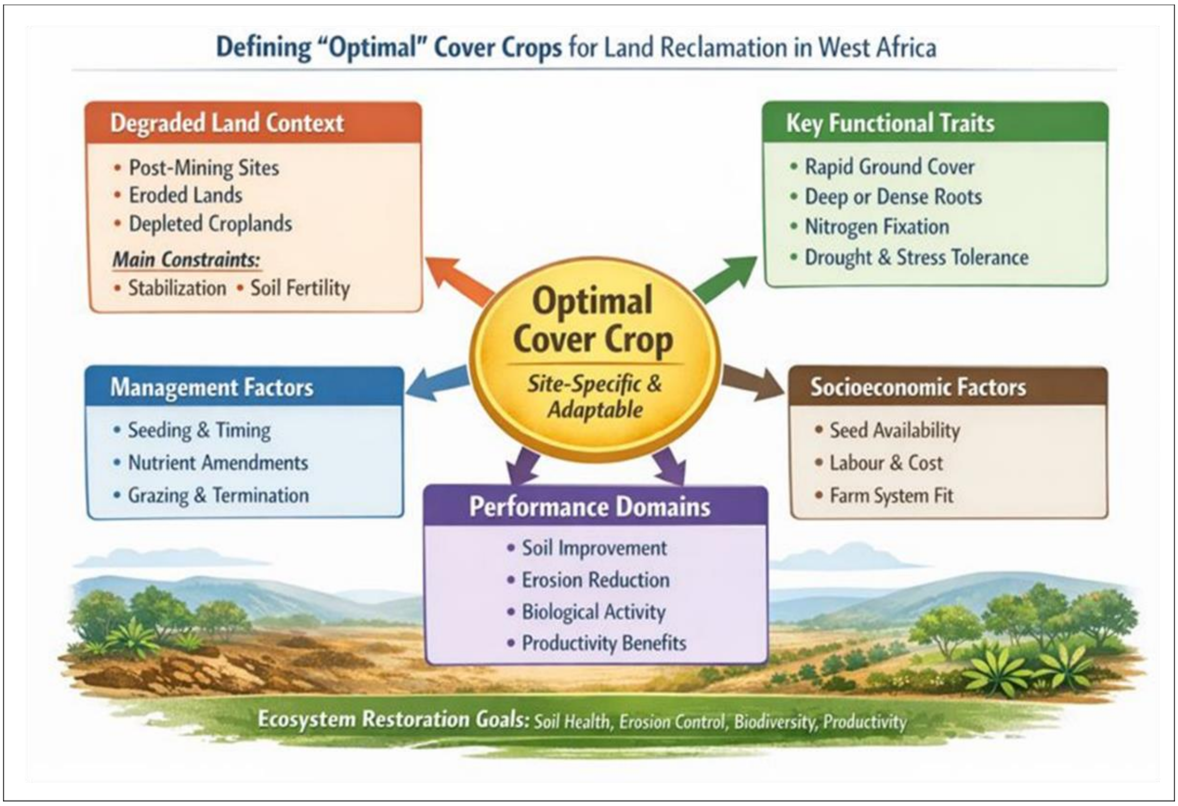

Fig. 1. Defining "optimal" cover crops for land reclamation in West Africa

4. Literature Search Strategy

A comprehensive literature search was carried out to identify relevant published and grey literature. Major scientific databases, including Web of Science, Scopus, PubMed, African Journals Online, and Google Scholar, were searched. Institutional reports from international agricultural and environmental organisations were also reviewed. Search terms combined keywords related to cover crops, land reclamation, soil rehabilitation, ecosystem services, and West Africa. Reference lists of relevant articles were further screened to identify additional studies not captured during the initial search.

4.1 Eligibility Criteria

Studies were selected based on predefined inclusion and exclusion criteria. Studies were included if they evaluated one or more cover crop species or mixtures, conducted in West Africa or comparable environments, and reported outcomes related to soil improvement, vegetation recovery, or ecosystem services. Field-based and applied studies were prioritised. Studies were excluded if they focused only on crop yield without soil or ecological outcomes, were limited to greenhouse or pot experiments, or lacked sufficient methodological detail to support interpretation (Moher et al., 2009).

4.2 Study Selection Process

All identified records were first screened by title to remove clearly irrelevant studies. Abstracts of the remaining studies were then reviewed to assess their relevance to cover crops and land reclamation. Full-text articles were examined for studies that met the inclusion criteria. This stepwise screening process helped to reduce bias and ensured that only relevant and methodologically sound studies were included in the review (Vrabel, 2015).

4.3 Data Extraction and Management

A standardised data extraction framework was used to collect key information from each included study. Extracted data included study location, agroecological zone, soil type, and type of land degradation addressed. Information on cover crop species, functional group, management practices, and duration of the study was also recorded. Outcome variables related to establishment success, biomass production, soil physical and chemical properties, erosion control, and ecosystem benefits were systematically documented (Turnbull et al., 2023).

4.4 Classification of Cover Crops and Functional Traits

Cover crops identified in the literature were grouped into functional categories to allow meaningful comparison. These categories included legumes, grasses or cereals, broadleaf non-legumes, and multi-species mixtures. Functional traits such as growth rate, rooting depth, biomass production, nitrogen fixation ability, and tolerance to drought or poor soils were used to explain differences in performance across reclamation contexts (Grant and Booth, 2009).

4.5 Data Synthesis and Analysis

Due to variation in study design and reported outcomes, results were synthesised using a narrative approach. Studies were compared based on agroecological zone, type of land degradation, and cover crop functional group. Trends in soil recovery, erosion control, and ecosystem benefits were identified across studies. Where comparable quantitative data were available, the direction and consistency of effects were assessed to support conclusions on cover crop performance (Bown and Sutton, 2010, List and Axelsson, 2010).

4.6 Agroecological Context of West Africa and Its Relevance to Cover Crops

4.6.1 Climate Zones Relevant to Cover Crops in West Africa

West Africa consists of several climate zones that strongly influence the growth and performance of cover crops used for land reclamation (Boulet et al., 2021). These zones include the humid forest zone, the forest–savanna transition zone, the savanna zone, and the Sahelian zone. The humid forest zone is characterized by high and evenly distributed rainfall and a long growing season (Boutagayout et al., 2023, Paracchini et al., 2020). Although water availability is generally not limiting in this zone, heavy rainfall can increase soil erosion and nutrient leaching, particularly on degraded lands. Cover crops selected for this zone must therefore grow rapidly and provide effective soil cover to reduce erosion and nutrient loss. The forest–savanna transition zone experiences moderate rainfall with a distinct wet and dry season. Soils in this zone are often intensively cultivated, and land degradation is common due to reduced fallow periods (Issaka et al., 2021). Cover crops in this zone must establish quickly at the onset of rainfall and complete their growth within a limited season. The savanna zone has lower and more variable rainfall, high temperatures, and a long dry season. In this environment, cover crops must tolerate drought stress and produce sufficient biomass to protect the soil surface during the dry season. The Sahelian zone has the lowest rainfall and the shortest growing season. Cover crops used in this zone must be drought tolerant, short in duration, and carefully managed to avoid competition with food crops for limited water resources (Andrieu et al., 2025).

4.6.2 Typical Soil and Major Constraints

Soil in West Africa is mainly highly weathered tropical soil with low natural fertility. One of the most widespread constraints is low soil organic carbon, which results from continuous cultivation, high temperatures, and rapid decomposition of organic matter (Romero Antonio et al., 2025). Low organic carbon reduces soil structure, water-holding capacity, and nutrient availability. Cover crops are therefore important for increasing organic matter inputs and improving soil health over time. Soil acidity is common, especially in the humid forest and transition zones, and can limit nutrient availability and crop growth (Tapsoba et al., 2020). Phosphorus deficiency is also widespread due to strong fixation in tropical soils, which reduces the effectiveness of both crops and nitrogen-fixing legumes. In degraded and post-mining lands, soil compaction and surface crusting further restrict root growth and water infiltration. In addition, seasonal drought in the savanna and Sahelian zones limits plant establishment and biomass production. Effective cover crops must therefore tolerate poor soil fertility, physical degradation, and water stress (Tapsoba et al., 2020).

4.6.3 Farming Systems and Land-Use Realities

Land reclamation using cover crops in West Africa takes place mainly within smallholder farming systems. These systems are characterized by small land sizes, low input use, and reliance on rainfall (Naazie et al., 2023). Farming is often integrated with livestock rearing, and crop residues play an important role as dry-season feed for animals. As a result, biomass produced by cover crops may be grazed, which can reduce their effectiveness in protecting the soil if grazing is not controlled. Traditional fallow systems, which once contributed to soil recovery, are becoming shorter or disappearing due to population pressure and land scarcity (Dagunga et al., 2023, Marfurt et al., 2023). Cover crops are therefore expected to restore soil functions within a short time. Labour availability also affects cover crop adoption, as farmers must manage cover crops alongside food crops. Cover crops that are easy to establish, manage, and terminate are more likely to be adopted by smallholder farmers (Silva et al., 2023). Limited access to quality seed further influences which cover crops are suitable for wide use. The wide variation in climate, soils, and farming systems across West Africa means that no single cover crop is suitable for all situations. Cover crop selection must consider rainfall availability, soil fertility constraints, cropping calendars, and livestock pressure (Djihouessi et al., 2022). In high-rainfall areas, cover crops that provide rapid ground cover and erosion control are most suitable. In dry areas, drought-tolerant and short-duration species are preferred. Where livestock grazing is common, cover crops must either tolerate grazing or produce enough biomass to meet both soil protection and feed needs (Romero Antonio et al., 2025, Qiu et al., 2024). The timing of planting and the persistence of residues during the dry season are critical factors in determining the success of cover crops for land reclamation (Boutagayout et al., 2023).

5. Cover Crop Functional Traits Important for Land Reclamation

5.1 Canopy Development, Biomass Production, and Residue Quality

Canopy development, biomass production, and residue quality are closely linked traits that determine how effectively a cover crop protects and improves degraded land (Sutton et al., 2025). Cover crops that establish quickly and form dense canopies protect the soil surface from direct rainfall impact, which reduces erosion, surface sealing, and soil crusting. Early canopy cover also lowers soil temperature and reduces evaporation, helping to conserve soil moisture and support soil biological activity (Fernandez Pulido et al., 2025, Quintarelli et al., 2022). In degraded and post-mining lands, rapid ground cover is particularly important because exposed soils are highly vulnerable to further degradation. High biomass production increases the amount of organic matter returned to the soil. This organic matter improves soil structure, increases soil organic carbon, and enhances the soil's ability to hold water and nutrients (Hudek et al., 2022). However, the quality of the biomass is as important as the quantity. Residues with low carbon-to-nitrogen ratios decompose quickly and release nutrients rapidly, which is useful for short-term soil fertility improvement. Residues with higher carbon-to-nitrogen ratios decompose more slowly and remain on the soil surface for longer periods, providing sustained soil cover and erosion control. An effective cover crop for land reclamation should therefore balance rapid canopy development with adequate biomass production and suitable residue quality (Garba and Williams, 2023, Kocira et al., 2020).

5.2 Root Systems, Soil Structure, and Water Relations

Root system characteristics play a major role in improving soil physical conditions during land reclamation. Deep-rooted cover crops can penetrate compacted soil layers and hardpans that restrict root growth and water movement. By creating channels in the soil, these roots improve infiltration, drainage, and soil aeration (Małecki et al., 2021). This process increases the availability of water and nutrients for subsequent crops and improves overall soil resilience to drought. Fibrous-rooted cover crops, on the other hand, form dense root networks near the soil surface. These roots bind soil particles together, improve aggregate stability, and reduce surface erosion (Małecki et al., 2021). They are particularly effective in stabilizing topsoil on sloping or highly eroded lands due to their dense and reinforcing root systems (Hudek et al., 2022, Kocira et al., 2020, Małecki et al., 2021). When deep-rooted and fibrous-rooted cover crops are used together, either as mixtures or in sequence, they provide complementary benefits that improve both surface and subsoil conditions (Garba and Williams, 2023, Chen et al., 2025, Zhang et al., 2022).

5.3 Nutrient Cycling, Nitrogen Fixation, and Soil Biological Activity

Nutrient cycling is a key function of cover crops in land reclamation. Leguminous cover crops improve soil fertility through biological nitrogen fixation, which converts atmospheric nitrogen into plant-available forms (Sutton et al., 2025). This process reduces the need for chemical nitrogen fertilizers, which are often costly or unavailable to smallholder farmers. The amount of nitrogen fixed depends on soil moisture, soil acidity, phosphorus availability, and the presence of effective rhizobia. After decomposition, nitrogen from legume residues becomes available to subsequent crops (Quintarelli et al., 2022). At the same time, organic inputs from cover crops stimulate soil microbial activity, which improves nutrient cycling and enhances soil biological health. Increased microbial activity supports the breakdown of organic matter and the release of nutrients, contributing to long-term soil fertility restoration. Both leguminous and non-leguminous cover crops therefore play important roles in improving nutrient availability through different but complementary mechanisms (Chen et al., 2025).

5.4 Stress Tolerance and Adaptation to Poor Soil Conditions

Stress tolerance is an essential trait for cover crops used in land reclamation in West Africa. Many degraded soils have low fertility, high acidity, or nutrient imbalances that limit plant growth (Mariani and Ferrante, 2017). In addition, some reclamation sites, particularly post-mining areas, may contain elevated levels of heavy metals. Cover crops that can tolerate these conditions are important for stabilizing soils and initiating recovery processes. Drought and heat tolerance are especially important in the savanna and Sahelian zones, where rainfall is limited and temperatures are high (Anli et al., 2020). Drought-tolerant cover crops are better able to survive dry spells and still provide soil cover. Short-duration species are suitable for areas with short and unpredictable rainy seasons, while longer-duration species may be used where rainfall is more reliable. By tolerating harsh conditions, these cover crops create a more favourable soil environment for later stages of land reclamation (Pequeno et al., 2021).

5.5 Integration with Farming Systems, Weed Control, and Pest Dynamics

For cover crops to be effective and widely adopted, they must fit well within existing farming systems. In West Africa, land availability is often limited, and farmers rely on mixed crop–livestock systems (Sutton et al., 2025). Cover crops are therefore commonly grown alongside food crops, after harvest, or within crop rotations. Suitable cover crops should not compete strongly with main crops for water or nutrients and should be easy to manage and terminate. Weed suppression is an important benefit of many cover crops. Dense canopies reduce weed emergence by limiting light, water, and nutrient availability (Hussain et al., 2020).

Some cover crops also suppress weeds through chemical effects. While these benefits reduce labour and input costs, strong competition or allelopathic effects may negatively affect subsequent crops if not properly managed (Serba et al., 2020). Cover crops can also influence pest and disease dynamics. Some species help reduce pest populations by disrupting pest life cycles or supporting natural enemies, while others may act as alternative hosts for pests and diseases. These interactions must be carefully considered to ensure that cover crops contribute to long-term system sustainability rather than creating new management challenges (Zhang et al., 2024).

5.6 Candidate Cover Crops in West Africa: Evidence by Crop Group

This section reviews the main groups of cover crops used in West Africa for land reclamation. The discussion focuses on how these crops are adapted to local conditions, how they perform on degraded soils, the ecosystem services they provide, and the main limitations that affect their use. Attention is also given to the types of environments where each crop group is most suitable. Evidence is drawn from field experiments, on-farm studies, and land rehabilitation projects conducted across different agroecological zones in the region (Table 1).

5.7 Leguminous Cover Crops for Soil Fertility Improvement and Biomass Production

Leguminous cover crops are widely used in West Africa because they improve soil fertility while also producing useful biomass (Hussain et al., 2020, Barney et al., 2009, Issaka et al., 2021, Koza et al., 2022). Many legumes are well adapted to tropical climates and can grow on soils with low nitrogen levels. Commonly used herbaceous legumes include *Mucuna pruriens*, *Lablab purpureus*, *Vigna unguiculata* (cowpea), *Arachis hypogaea* (groundnut), *Cajanus cajan* (pigeon pea), and *Stylosanthes* species. These crops differ in growth form, length of growth cycle, and tolerance to drought or poor soils, but they all contribute organic matter and biological nitrogen to the soil (Quintarelli et al., 2022). In terms of performance, herbaceous legumes usually establish well at the beginning of the rainy season when soil moisture is available. Species such as *Mucuna pruriens* and *Lablab purpureus* show vigorous early growth and rapid canopy closure, which helps to protect the soil surface and suppress weeds (Liliane and Charles, 2020). Short-duration legumes such as *Vigna unguiculata* and *Arachis hypogaea* fit easily into crop rotations and are suitable for smallholder farming systems where land is limited. *Cajanus cajan* has a deeper root system and a longer growth period, which allows it to access deeper soil moisture and improve soil structure. *Stylosanthes* species are often used in fallow or pasture systems because they tolerate grazing and persist over several seasons (Serba et al., 2020). Leguminous cover crops provide important ecosystem services. Through biological nitrogen fixation, they increase soil nitrogen availability and reduce the need for mineral fertilizers. Their residues add organic matter to the soil, improve soil organic carbon levels, and enhance soil aggregation. Dense legume canopies reduce weed pressure by limiting light availability at the soil surface. Over time, repeated use of legumes improves water infiltration and supports soil biological activity, which is essential for restoring degraded soils (Younis et al., 2020).

Despite these advantages, leguminous cover crops also have limitations. Nitrogen fixation is often reduced in acidic soils and in soils with low phosphorus availability, both of which are common in West Africa (Raza et al., 2020). Establishment may be poor on severely degraded or compacted soils without initial soil improvement. Some vigorous legumes may compete with food crops for water if grown together. In addition, access to quality seed and inoculants can be limited, which restricts adoption in some areas. Leguminous cover crops are best suited to nutrient-depleted croplands, shortened fallow systems, and moderately degraded lands where soil fertility improvement is a major objective. They perform particularly well in the humid forest and transition zones, while drought-tolerant species such as *Cajanus cajan* and *Vigna unguiculata* are more suitable for savanna environments. Tree and shrub legumes are important for longer-term land rehabilitation. Species such as *Gliricidia sepium* are commonly used in agroforestry and alley cropping systems (Garba and Williams, 2023).

These plants are well adapted to tropical climates, tolerate repeated pruning, and provide continuous inputs of organic matter through leaf fall and pruning residues. Their deep roots improve soil structure and recycle nutrients from deeper soil layers. However, they require more time to establish and are therefore more suitable for long-term rehabilitation than for short-term reclamation (Benaffari et al., 2022).

5.8 Grasses and Cereals as Cover Crops for Erosion Control and Soil Stabilization

Grasses and cereal cover crops are mainly used for their strong ability to control erosion and stabilize soils. These crops are generally well adapted to a wide range of climatic conditions in West Africa and can establish rapidly when moisture is available (Fageria et al., 2005). Commonly used grasses and cereals include species of *Brachiaria*, *Pennisetum*, *Sorghum*, and *Zea mays* when grown primarily for cover rather than grain. Their fibrous root systems are effective in holding soil particles together and reducing runoff on degraded land (Vanlauwe et al., 2003). In terms of performance, grasses and cereals produce rapid ground cover and large amounts of biomass. Their residues often have high carbon-to-nitrogen ratios, which slow decomposition and allow residues to remain on the soil surface for long periods. This persistent cover is especially valuable in savanna and Sahelian zones, where soils are exposed to erosion during long dry seasons. Grasses also improve soil aggregation and reduce surface crusting, which enhances water infiltration. The ecosystem services provided by grasses include effective erosion control, increased carbon inputs to the soil, and improved soil physical stability (Basu et al., 2016). By reducing runoff and increasing infiltration, grass cover crops improve water management on degraded lands. Their extensive root systems also help reduce wind erosion in dry and open landscapes. A key trade-off associated with grasses is the temporary immobilization of soil nitrogen during residue decomposition. This can reduce nitrogen availability for subsequent crops, especially when grasses are used alone. Grasses may also compete with crops for soil moisture if not properly timed or managed (Barney et al., 2009). For these reasons, grasses are often more effective when combined with legumes. Grasses and cereals are best suited to severely eroded fields, sloping lands, post-mining sites, and dryland environments where soil stabilization is the main goal. Their benefits are enhanced when they are integrated with leguminous cover crops that improve soil fertility (Kocira et al., 2020).

5.9 Brassicas and other Broadleaf Non-Leguminous Cover Crops

Brassicas and other non-leguminous broadleaf cover crops are less commonly used in West Africa, but they provide specific benefits in certain environments. Examples include *Brassica juncea* and *Raphanus sativus* (Barney et al., 2009). These crops are generally better adapted to cooler conditions and may perform well in highland areas or under irrigation. As a result, their use is limited to specific niches rather than widespread rainfed systems. In terms of performance, brassicas can produce substantial biomass within a short period and develop strong taproots that penetrate compacted soils. Some brassica species release biologically active compounds during residue breakdown, which can suppress soil-borne pests and pathogens (Benaffari et al., 2022). This biofumigation effect can be useful in reclaimed lands where pest pressure is high. The ecosystem services provided by brassicas include pest and disease suppression, improvement of soil porosity, and short-term organic matter inputs. These crops can help improve soil conditions before the establishment of more sensitive crops (Younis et al., 2020). However, brassicas face several constraints. Seed availability is often limited, and seed costs can be high. These crops are also sensitive to high temperatures and drought, which reduces their performance under typical low-input rainfed conditions (Sharma et al., 2021). Therefore, brassicas are best suited to cooler highland zones, irrigated systems, or controlled reclamation projects.

5.10 Performance of Cover Crops in West Africa in Soil Reclamation

The review showed that all evaluated cover crops adapted well to West African conditions, with both native and exotic species performing effectively. Most species had fast growth and annual life cycles, except Stylosanthes hamata, which is perennial and offers long-term ground cover benefits (Hudek et al., 2022). All crops exhibited high drought and pest resistance, with Sesbania rostrata also showing strong tolerance to salinity. Phytoremediation potential was high for all species, particularly legumes, which improved nitrogen fixation, organic matter levels, and heavy metal uptake in degraded soils

Table 1. Performance of Cover Crops in West Africa in Soil reclamation

Location and Agro ecological	Cover-Crop Species or System	Agronomic and Soil Parameters	Implementation Characteristics	References
Ghana, Alfisols, Forest/Savanna transition zone	*Mucuna pruriens* (Legume)	SOC ↑ 21%, Maize yield ↑ 1.2 t/ha	Duration: 1 year, Seeding: Broadcast, Termination: Mowing, Use: Fallow	(Adjei-Nsiah et al., 2008)
Ghana, Mining spoils	*Crotalaria juncea, Canavalia ensiformis* (Legumes)	N input 100–150 kg N/ha/year, Biomass 6–8 t/ha	Duration: 1 year, Seeding: Direct, Termination: Mowing, Use: Fallow	(Danso et al., 1992)
Nigeria, Alfisols, Savanna	*Mucuna pruriens* (Legume)	N fertilizer equivalency 60–80 kg N/ha	Duration: 1 year, Seeding: Broadcast, Termination: Mowing, Use: Fallow	(Aliyu et al., 2004)
Nigeria, Ultisols, Acid, P-deficient soils	*Canavalia ensiformis* (Legume)	P uptake ↑ 40%, Grain yield ↑ 1.5 t/ha	Duration: 1 year, Seeding: Direct, Termination: Mowing, Use: Fallow	(Oikeh et al., 2008)
Burkina Faso, Semi-arid, Degraded soils	*Stylosanthes hamata* (Legume)	Runoff ↓ 50%, SOC ↑ 0.3%	Duration: 1 year, Seeding: Broadcast, Termination: Mowing, Use: Fallow	(Terrasson and Mojaisky, 2008)
Burkina Faso, Low-fertility soils	Crotalaria ochroleuca (Legume)	120 kg N/ha fixed, Biomass 5–6 t/ha	Duration: 1 year, Seeding: Direct, Termination: Mowing, Use: Fallow	(Bostick et al., 2007)
Senegal, Saline soils, Saloum delta	*Sesbania rostrata, Vigna unguiculata* (Legumes)	Electrical conductivity ↓ 25%, Rice yield ↑ 1.1 t/ha	Duration: 1 year, Seeding: Direct, Termination: Mowing, Use: Fallow	(Diédhiou, 2021)

Table 2. Decision framework for matching cover crops to land reclamation scenarios in West Africa

Reclamation scenario	Main constraints	Priority functions	Recommended cover crop traits	Suitable cover crop groups / examples	Key management notes
Post-mining lands, tailings, spoil sites	No or shallow topsoil, compaction, very low organic matter, nutrient deficiency, possible heavy metals, high erosion risk	Rapid soil stabilisation, erosion control, initiation of biological activity	High tolerance to poor soils, fast establishment, strong rooting, ability to grow on bare substrates	Early stage: grasses with fibrous roots; tolerant herbaceous legumes. Later stage: productive legumes and shrub/tree legumes	Use a staged approach. Start with pioneer species, then introduce more demanding legumes as soil conditions improve
Severely eroded croplands	Loss of topsoil, low organic matter, poor structure, high runoff	Fast soil cover, soil binding, residue persistence	Rapid canopy closure, dense root systems, good residue persistence	Grasses, fast-growing legumes, grass–legume mixtures	Maintain surface residues during dry season; avoid complete residue removal for grazing

Reclamation scenario	Main constraints	Priority functions	Recommended cover crop traits	Suitable cover crop groups / examples	Key management notes
Low fertility and nutrient-depleted soils	Nitrogen deficiency, low organic matter, declining yields	Soil fertility restoration, organic matter build-up	Biological nitrogen fixation, moderate to high biomass production	Herbaceous legumes; legume–grass mixtures	Ensure good establishment of legumes; mixtures help balance nutrients and soil cover
Dry savanna and Sahelian margins	Low and variable rainfall, high temperatures, drought risk, grazing pressure	Soil protection with minimal water use	Drought tolerance, short growth cycle, grazing tolerance	Short-duration legumes and grasses adapted to dry conditions	Plant at onset of rains; select species that can also serve as forage where grazing is common
Coastal and saline environments	Salinity, poor drainage, periodic flooding	Soil stabilisation, gradual soil improvement	Salt tolerance, tolerance to waterlogging	Salt-tolerant cover crops where available (evidence still limited)	Site-specific testing needed; research gaps remain for West Africa
Agroforestry systems and plantation understories (cocoa, cashew, oil palm)	Shade, competition with trees, need for mulch	Weed suppression, soil protection, mulch supply	Shade tolerance, moderate biomass, controlled decomposition	Shade-tolerant legumes and low-growing covers	Ensure compatibility with harvesting and routine plantation management

(Sutton et al., 2025). Soil fertility improved significantly across species, indicated by increased microbial biomass carbon, microbial biomass nitrogen, and soil respiration. Soil biological activity, measured by enzyme activity and earthworm abundance, was highest for *Mucuna pruriens* and *Sesbania rostrata*. Adaptability to local conditions was high for all species, with native species matching or surpassing exotic species under resource-limited farming systems (Abayomi et al., 2001). Ease of establishment was generally high, except for *Stylosanthes hamata*, which required more initial management. Competitiveness with weeds was strong across all species, reducing herbicide needs and supporting sustainable farming. Biomass production was high for all species, especially *Mucuna pruriens*, *Crotalaria juncea*, and *Canavalia ensiformis*. Resilience to climate change was strong in all species, with *Mucuna pruriens*, *Crotalaria juncea*, and *Sesbania rostrata* ranking highest in overall suitability (Raza et al., 2020).

6. Matching Cover Crops to Reclamation Scenarios in West Africa

Successful land reclamation in West Africa depends not only on the choice of cover crop species but also on how well those species are matched to specific degradation scenarios. Different forms of land degradation create different limitations related to soil, water, and management. As a result, cover crops must be selected to address the most serious constraints at each site. This section presents a decision-oriented narrative that links common reclamation scenarios in West Africa with suitable cover crop traits and management priorities. The purpose is to guide practical and context-specific selection rather than to recommend a single solution for all environments (Table 2).

6.1 Post-Mining Lands, Tailings, and Damage Sites

Post-mining lands, including tailings and spoil heaps, are among the most severely degraded landscapes in West Africa. These sites often have extremely poor soil structure, very low or no topsoil, minimal organic matter, and severe nutrient deficiencies. In some cases, soils may also contain elevated levels of heavy metals or toxic compounds (Abayomi et al., 2001). Water infiltration is usually poor, and erosion risk is very high. The main priorities in these environments are rapid soil stabilisation, control of erosion, and the gradual re-establishment of biological processes. During the early stage of reclamation, cover crops must be highly tolerant of harsh soil conditions and capable of establishing on bare or unstable surfaces (Hudek et al., 2022). Fast-growing species with strong and extensive root systems are particularly important at this stage because they reduce surface runoff and hold loose soil in place. Grasses with fibrous roots are often suitable as pioneer cover crops because they bind surface materials and reduce wind and water erosion. Where soil conditions allow, tolerant leguminous cover crops can also be introduced to provide nitrogen and organic matter (Małecki et al., 2021). As soil conditions improve over time, later stages of reclamation can support a wider range of cover crops. At this stage, more productive legumes and shrub or tree legumes can be introduced to increase biomass production, enhance nutrient cycling, and improve soil structure (Liliane and Charles, 2020). These species contribute larger amounts of organic matter and support microbial activity, which is important for long-term soil recovery. This gradual transition from tolerant pioneer species to more demanding cover crops follows a successional approach that is suitable for post-mining landscapes (Tarolli et al., 2024).

6.2 Severely Eroded Croplands

Severely eroded croplands are widespread in West Africa, especially on sloping land and in areas exposed to intense rainfall. These soils often have shallow topsoil, low organic matter, poor aggregation, and reduced water-holding capacity. Crop productivity is usually low, and erosion continues if the soil surface remains exposed (Sharma et al., 2021). The main objective in these systems is to provide rapid soil cover while improving soil stability. Cover crops used on eroded croplands must establish quickly and form dense canopies that protect the soil from rainfall impact. Grasses and fast-growing legumes are particularly effective because they combine rapid ground cover with strong root systems that stabilise the soil. Residue persistence is also important, as crop residues left on the soil surface protect the soil during the dry season and reduce further erosion. In many cases, mixtures of grasses and legumes perform better than single species because they provide both physical protection and soil fertility improvement (Kocira et al., 2020).

6.3 Low Fertility and Nutrient-Depleted Soils

Low fertility and nutrient-depleted soils are common in West Africa as a result of continuous cultivation, limited fertiliser use, and reduced fallow periods. These soils are often low in nitrogen and organic matter and show declining productivity over time. In such systems, the main aim of reclamation is to rebuild soil fertility while maintaining adequate soil cover (Sharma et al., 2021). Leguminous cover crops are particularly suitable for these conditions because they fix atmospheric nitrogen and add organic matter to the soil. Herbaceous legumes can be grown during short fallow periods or integrated into crop rotations to restore soil nutrients. When legumes are combined with grasses in mixed systems, the grasses contribute residue persistence and soil protection, while the legumes improve nutrient availability. This combination supports gradual soil fertility recovery without heavy reliance on external inputs (Vanlauwe et al., 2003).

6.4 Dry Savanna and Sahelian Margins

Dry savanna and Sahelian margin environments pose strong challenges for cover crop use due to low and variable rainfall, high temperatures, and frequent drought. In these areas, water availability is the most limiting factor, and cover crops must be selected carefully to avoid reducing water available to food crops. Cover crops for dryland environments should be drought-tolerant, short in duration, and able to establish quickly when rainfall begins. Species that complete their growth cycle within a short rainy season are more reliable under these conditions. Grazing tolerance is also an important consideration because many dryland farming systems include livestock. Cover crops that can provide both soil cover and forage are more likely to be accepted by farmers, especially where residue use for livestock feed is common (Raza et al., 2020).

6.5 Coastal and Saline Environments

Coastal and saline environments occur in several parts of West Africa, particularly along the Atlantic coastline. Soils in these areas may be affected by salt accumulation, poor drainage, and periodic flooding. These conditions limit plant growth and reduce the range of cover crops that can survive. In such environments, salt-tolerant cover crops are preferred where evidence supports their use (Ntshidi et al., 2021). These species help stabilise the soil surface, reduce erosion, and improve soil structure over time. However, research on cover crop use in saline environments in West Africa is limited. More location-specific studies are needed to identify suitable species and management practices for these conditions (Benaffari et al., 2022).

7. Discussion

This review synthesised available evidence on the use of cover crops for land reclamation in West Africa. Particular emphasis on performance, adaptability, ecosystem services, and context-specific suitability (Sharma et al., 2021). The findings indicate that cover crops can play a significant role in restoring degraded lands, but their success depends strongly on how well they are matched to local environmental conditions and land-use systems (Sharma et al., 2021). Rather than a single optimal cover crop, the evidence supports a scenario-based approach that considers the type and severity of land degradation, climate conditions, soil constraints, and management capacity (Fageria et al., 2005). Across West Africa, land degradation is driven by multiple interacting factors, including soil erosion, nutrient depletion, mining activities, deforestation, and climate variability. Cover crops address several of these challenges simultaneously by protecting the soil surface, improving soil structure, increasing organic matter inputs, and enhancing nutrient cycling. However, the magnitude and speed of these benefits vary widely among crop groups and environments. This variability explains why results from cover crop interventions are often inconsistent when context is not adequately considered (Tarolli et al., 2024).

Leguminous cover crops emerged as particularly important for reclaiming nutrient-depleted soils. Their ability to fix atmospheric nitrogen and contribute organic matter makes them well suited to systems affected by continuous cultivation and shortened fallow periods. In many cases, legumes also provide additional benefits such as weed suppression and support for soil biological activity (Basu et al., 2016). However, their performance is constrained by soil acidity, phosphorus deficiency, and poor physical soil conditions. This highlights the need for complementary practices, such as minimal soil amendment or the use of tolerant pioneer species, especially in severely degraded areas. Grasses and cereal cover crops were shown to be highly effective for erosion control and soil stabilisation, especially on sloping lands, post-mining sites, and dry environments (Raza et al., 2020). Their fibrous root systems and persistent residues provide strong physical protection to the soil. Nevertheless, the potential for temporary nitrogen immobilisation and competition for water must be carefully managed. The evidence consistently indicates that combining grasses with legumes reduces these trade-offs and improves overall system performance (Boutagayout et al., 2023).

Multi-species cover crop mixtures represent a promising strategy for increasing system resilience under variable climatic conditions. By combining species with different functional traits, mixtures can deliver multiple ecosystem services at the same time (Abayomi et al., 2001). The reviewed evidence (Paracchini et al., 2020, Naazie et al., 2023, Dagunga et al., 2023, Wakweya, 2023) suggests that mixtures often provide more stable biomass production and ground cover than single-species stands, particularly under erratic rainfall. However, increased management complexity and limited seed availability may restrict their widespread adoption among smallholder farmers. The scenario-based framework developed in this review provides a practical tool for selecting cover crops according to specific reclamation needs (Raza et al., 2020). Post-mining landscapes require a staged approach, starting with tolerant pioneer species and progressing towards more productive legumes and agroforestry species as soil conditions improve (Marfurt et al., 2023). Severely eroded croplands benefit most from fast-establishing species that provide immediate soil cover and root reinforcement. In dry savanna and Sahelian environments, drought tolerance, short growth duration, and grazing compatibility are critical selection criteria. Plantation and agroforestry systems require shade-tolerant cover crops that integrate well with existing management practices (Silva et al., 2023).

Despite the demonstrated potential of cover crops, important knowledge gaps remain. There is limited long-term evidence on cover crop performance in post-mining and saline environments in West Africa. Many studies are short-term and focus on individual indicators rather than integrated ecosystem outcomes. Socioeconomic factors, including labour requirements, seed access, and competing uses for biomass, are also underrepresented in the literature. Addressing these gaps will be essential for scaling up cover crop–based reclamation strategies.

8. Conclusion

This review shows that cover crops are an effective and flexible option for land reclamation in West Africa. They protect the soil, improve fertility, support biological activity, and provide multiple ecosystem services, but their success depends on careful selection and management suited to local environmental and socioeconomic conditions. There is no single cover crop that is suitable for all reclamation situations. Effective land recovery requires matching cover crop functional traits to specific degradation problems. Legumes are most useful for restoring soil fertility, grasses are important for erosion control and soil stabilisation, and mixed systems provide a balanced and resilient approach. In severely degraded areas such as post-mining lands, a phased strategy using tolerant species first and more productive crops later is necessary. Appropriately selected and well-managed cover crops provide a low-cost and environmentally sound pathway for restoring degraded lands and supporting long-term agricultural productivity in West Africa.

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Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Competing Interests

Authors have declared that no competing interests exist.

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