CODE HEMP

Combat Desertification through Industrial Hemp

Feasibility study for semi-arid areas and the dry savannah
with the Great Green Wall as a showcase for hemp-based value chains

Linnaeus Competence Center Hemp

German Federal Association for Sustainability

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Foreword

The Great Green Wall (GGW) is one of the most ambitious restoration projects of our time. Launched in 2007, it set out to restore 100 million hectares of degraded land, sequester 250 million tons of CO_2, and create 10 million jobs by 2030. The vision captured global imagination, presenting Africa as a leader in responding to desertification, land degradation, and climate change.

Eighteen years later, in 2025, while there are notable success stories in Ethiopia, Senegal, and Niger, implementation is fragmented and far behind the ambition. Tree planting alone, though essential, has proven insufficient — seedlings require years of care, protection, and water before they deliver ecological or social impact. The urgency of the climate crisis, combined with population growth and economic pressures in the Sahel, demands solutions that deliver results faster, while remaining sustainable in the long term.

This feasibility study is relevant for semi-arid and savannah regions worldwide, but it uses the **Great Green Wall as its exemplary case study**. The GGW embodies both the challenges and opportunities of combating desertification: fragmented implementation on the one hand, and on the other, the immense potential to regenerate landscapes, create livelihoods, and harness climate finance. By focusing on this region, CODE HEMP demonstrates how **industrial hemp** can complement tree planting by offering rapid ecological impact, diversified economic value chains, and bankable carbon removals. The lessons drawn here will have significance far beyond Africa, providing a replicable model for dryland regions across the globe.

Industrial hemp is not an alternative to trees, but a **catalyst for systemic change**. With its deep roots, rapid growth cycle, and adaptability to semi-arid conditions, it delivers impact within a single season. Its value chains span food, construction, textiles, cellulose, biocomposites, and biochar — all of which create employment and income opportunities. Crucially, industrial hemp opens access to **carbon finance**, with durable carbon removals (such as biochar and hemp-lime construction) recognized as some of the most credible and sought-after solutions on global markets. In 2025, as demand for high-integrity carbon removals continues to surge, this offers a historic opportunity to align restoration with sustainable finance.

Our study set out to ask a straightforward but urgent question: *Can industrial hemp support the Great Green Wall by linking ecological restoration with viable business and financial models?* The findings suggest that it can. Hemp generates income for farmers within a single season, empowers women and youth through cooperative structures, and establishes carbon revenue streams that can make restoration financially sustainable.

CODE HEMP is not only a concept but a **practical roadmap**. It proposes a staged approach:

- A **pilot in Spain** (2026–2027) to establish scientific credibility through life-cycle assessments and carbon accounting.
- A **demonstrator in Ghana** (2027–2029) to validate social, economic, and gender-inclusive models.
- A **scale-up across the Sahel** (2029–2035) through public–private partnerships and blended finance mechanisms.

Each stage reduces risk and builds credibility: Spain proves the science, Ghana proves the socio-economic model, and the Sahel scale-up proves continental impact. For us, this project is not only about crops or carbon. It is about **people and dignity**. Women — who contribute most to agriculture but remain marginalized in land ownership and finance — will be central actors in CODE HEMP, leading cooperatives and processing units. Youth — too often forced to leave rural areas due to lack of opportunities — will find meaningful employment and entrepreneurship prospects in hemp value chains. Communities will not be passive beneficiaries but active co-creators of a new restoration economy.

The Great Green Wall has always been a symbol of ambition. From 2026 onwards, it must become a symbol of **innovation, inclusivity, and investment**. CODE HEMP embodies all three. By aligning with international frameworks the project ensures that its impacts are measurable, verifiable, and credible for investors, donors, and communities alike.

This foreword is therefore also a **call to action**. We invite policymakers to enable hemp as a restoration crop, donors to support its pilots and demonstrators, investors to back its hubs and carbon credits, and communities to lead in shaping its future. The Great Green Wall cannot wait. The challenges are too urgent, the opportunities too great, and the stakes too high.

Key Messages

- **Why industrial hemp?** Because it combines ecological regeneration with diversified economic value chains and durable carbon finance.
- **Why now?** Because 2025 is a decisive moment: the GGW lags behind targets, while demand for high-integrity carbon removals is at an all-time high.
- **Why CODE HEMP?** Because it offers a staged, bankable roadmap that integrates science, livelihoods, and investment into one replicable model.

Berlin (Germany), October 2025

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About the Editors

This feasibility study was prepared under the joint editorial responsibility of two organizations working at the intersection of sustainability, vocational education, and industrial hemp innovation.

Linnaeus Competence Center Hemp (Germany)

The Linnaeus Competence Center Hemp is a charitable research institute dedicated to applied research, vocational training, and innovation in the industrial hemp sector. It brings together expertise in agronomy, circular economy, materials science, and climate finance. Its mission is to develop future-proof jobs and curricula, establish sustainable value chains, and link hemp innovation with pressing global challenges such as land restoration and carbon removals. Linnaeus works across Europe and internationally with universities, SMEs, and policy institutions, ensuring that hemp is integrated into both educational systems and industrial transformation processes.

https://kompetenzzentrum-hanf.org/en/

German Federal Association for Sustainability (Germany)

The German Federal Association for Sustainability is an umbrella non-profit organization that since 2013 has been engaged in Vocational Education and Training for Sustainable Development (BBNE), European cooperation projects, and sustainability policy. BVNG supports SMEs in adapting to the twin challenges of green transformation and skills shortages, with over 600 companies reached to date. Through projects funded by the EU, the German government, and international donors, BVNG has developed innovative tools and networks that integrate sustainability principles into professional practice.

https://nachhaltigkeit.bvng.org/en/

Shared Mission

Together, the Linnaeus Competence Center Hemp and the German Federal Association for Sustainability combine sector-specific innovation with systemic sustainability expertise. This collaboration ensures that CODE HEMP is not only scientifically and economically viable but also aligned with broader policy frameworks such as the Great Green Wall, the EU Green Deal, and the UN Sustainable Development Goals.

Executive Summary

The Great Green Wall, launched in 2007 under the leadership of the African Union and supported by the UNCCD to restore 100 million hectares across the Sahel by 2030, remains one of the most ambitious land-restoration projects in the world. The vision was bold: an 8,000-kilometer mosaic of restored land, halting desertification, sequestering carbon, and creating millions of livelihoods.

By 2025, however, progress is uneven and well behind schedule: less than one-fifth of the target area has been restored, funding is fragmented, and tree-planting campaigns face high mortality rates in harsh climates. While the initiative has mobilized over 20 African countries, billions in pledges, and broad international support, its transformative potential is constrained by slow implementation and limited short-term benefits for local communities. Without complementary solutions that deliver faster ecological and economic returns, the GGW risks falling short of its original vision.

This feasibility study demonstrates that industrial hemp offers such a complementary pathway. Hemp establishes itself within months, stabilizes soils, improves water retention, and creates conditions that increase the survival rate of trees. At the same time, it generates diversified incomes through value chains in food, construction, textiles, biochar, and biocomposites. Crucially, hemp provides access to carbon finance, with durable removals such as hemp-lime construction and biochar already recognized in international markets.

Based on these findings, CODE HEMP proposes a three-step roadmap:

- **Pilot in Spain** (2026–2027) to generate robust scientific data, life-cycle assessments, and MRV protocols.
- **Demonstrator in Ghana** (2027–2029) to validate socio-economic models, cooperative structures, and carbon credit issuance.
- **Scale-up across the Sahel** (2029–2035) through public–private partnerships and blended finance, enabling replication across multiple GGW countries.

From these foundations, methodologies and value chains can be scaled across GGW countries. The approach combines scientific rigor, policy guidance, and investor engagement, positioning hemp not only as an agronomic solution but as a cornerstone of sustainable development in semi-arid regions.

The call to action is clear: integrate industrial hemp into the GGW portfolio, fund pilot and demonstrator projects, and unlock blended finance through climate funds, development aid, and private investment. Industrial hemp can transform from a neglected resource into

a missing link that accelerates ecological restoration, creates livelihoods, and secures the long-term success of the Great Green Wall.

To frame the urgency and the potential of CODE HEMP, the following fact boxes present a snapshot of both the Great Green Wall’s current status and the ecological and economic profile of

industrial hemp. Taken together, they highlight the gap between ambition and achievement in land restoration, and the opportunity for hemp to serve as a complementary accelerator.

Great Green Wall – Status in 2025

Indicator	Estimate / Statement
Hectares restored since start	~18 million hectares (to date)[1]
Projected sequestration by 2030	Current pace could deliver >300 million t CO_2[2]
Restoration shortfall	GGW likely to miss 2030 goal; only ~30% complete[3]
Restoration committed / pledges	USD 14 billion pledged; actual disbursements lag[4]
Tree survival / implementation challenges	High seedling mortality, fragmentation, weak coordination[5]
Countries participating	More than 20 countries engaged
Restored area as of report	Close to 20 million ha

Industrial Hemp at a Glance

Industrial hemp is a fast-growing, carbon-sequestering crop with multiple usable outputs—its biomass can be processed into bio-char, and its fiber and hurd components feed into textiles, construction materials, composites, food, and biopolymers. It offers a unique combination of ecological utility and economic value:

Metric / Characteristic	Typical Value / Range*	Notes / Caveats
Growth cycle	3–5 months	Depending on variety and climate
Yield (biomass / seed)	~2.3 tonne hemp per hectare (dry weight)	Used in LCA studies for CO_2 sequestration estimates[6]
CO_2 sequestered (plant)	~1.37 to 1.60 t CO_2 per tonne of hemp biomass	Based on chemical composition estimations[7]

[1]UNCCD -The Great Green Wall: Implementation Status and Way Ahead to 2030 Report: https://catalogue.unccd.int/1551_GGW_Report_ENG_Final_040920.pdf
[2] UNCCD - Independent Review of the Great Green Wall Accelerator: https://www.unccd.int/sites/default/files/2024-05/GGWA%20review%20final%20report%20formatted.pdf
[3] Reuters: Exclusive: Africa's Great Green Wall to miss 2030 goal says UN desertification president https://www.reuters.com/business/environment/africas-great-green-wall-miss-2030-goal-says-un-desertification-president-2024-06-12/
[4] Reuters: Exclusive: Africa's Great Green Wall to miss 2030 goal says UN desertification president https://www.reuters.com/business/environment/africas-great-green-wall-miss-2030-goal-says-un-desertification-president-2024-06-12/
[5] Goffner, D., Sinare, H. & Gordon, L.J. The Great Green Wall for the Sahara and the Sahel Initiative as an opportunity to enhance resilience in Sahelian landscapes and livelihoods. *Reg Environ Change* **19**, 1417–1428 (2019). https://doi.org/10.1007/s10113-019-01481-z
[6] Portland State University - Institute for Sustainable Solutions: https://www.pdx.edu/sustainability/sites/g/files/znldhr3181/files/2022-09/Industrial%20Hemp%20-%20A%20review%20of%20economic%20potential%20carbon%20sequetration%20and%20bioremediation%20ver16%20August18%202022.pdf
[7] ibid

Total CO_2 per hectare	~3.15 – 3.68 t CO_2 / ha (for 2.3 t hemp)	Conservative estimate from literature[8]
Biochar potential	High	Hemp biomass (especially stalks/hur ds) can be converted to biochar; the carbon is stabilized longer than in fresh biomass[9]
Other value-chains	Textiles, construction (hempcrete), food, composites, biopolymers, bio-char	Hemp materials already used in these sectors; hempcrete, composites and biopolymers act as a carbon sink over its life cycle; bio-char is a carbon sink for several 100 years[10]
Soil & ecological benefits	Soil stabilization, water retention, root penetration, erosion control	Hemp's root architecture and biomass input help soil structure and organic matter
Carbon credit / climate finance potential	Feasible	With proper methodological protocols (e.g. for hemp biochar) hemp projects can generate tradable CO_2 removals[11]

* These figures are approximate and depend heavily on local conditions (soil, climate, variety, agronomy).

[8] ibid
[9] Hemp Carbon Standard: Industrial Hemp Biochar - Methodology for CO2 Removal V1.2, 2025: https://hempcarbonstandard.org/wp-content/uploads/2025/04/Hemp-Biochar-Methodology-Final-V1.2-2.pdf
[10] BIOCHAR TODAY, The Promise of Industrial Hemp Residues for Sustainable Biochar Production: https://biochartoday.com/blog/the-promise-of-industrial-hemp-residues-for-sustainable-biochar-production/
[11] Hemp Carbon Standard: Industrial Hemp Biochar - Methodology for CO2 Removal V1.2, 2025: https://hempcarbonstandard.org/wp-content/uploads/2025/04/Hemp-Biochar-Methodology-Final-V1.2-2.pdf

Key Findings of this study

This feasibility study set out to assess whether industrial hemp can accelerate and complement restoration in semi-arid regions, using the Great Green Wall (GGW) as its case study. The findings confirm that industrial hemp can directly support the GGW in achieving its objectives, while also offering a scalable model for other dryland regions worldwide.

Core

Industrial hemp is more than an agronomic option: it is a systemic catalyst for the Great Green Wall. It restores land, creates livelihoods, empowers women and youth, unlocks carbon finance, and offers a clear pathway from pilots to continental scale. CODE HEMP demonstrates that the GGW can still achieve its goals — but only if it evolves into a restoration economy that integrates ecology, economy, and equity.

1. Alignment with the Great Green Wall

Industrial hemp strengthens the Great Green Wall by addressing its three core goals:

- **Land restoration**
  Industrial hemp stabilizes degraded soils, improves fertility, and creates favourable microclimates for tree growth, increasing survival rates of seedlings.
- **Livelihoods**
  It generates income within a single season, providing immediate returns for farmers and communities where tree planting alone takes years to deliver benefits.
- **Climate mitigation**
  Industrial hemp enables durable carbon removals through biochar and hemp-lime construction, and enhances soil organic carbon, aligning with global climate finance frameworks.

Together, these contributions make hemp a **catalyst for helping the GGW close the gap between ambition and reality**.

2. Ecological Findings

- Industrial hemp grows within four to five months, delivering **fast ecological impact** compared to tree-based interventions that take years.
- Its deep root system **stabilizes soils**, reduces erosion, improves water retention, and enhances organic matter.
- Industrial hemp functions as a **“bridge crop”**: protecting soils and creating conditions that increase tree survival and growth, making tree planting campaigns more effective.

3. Economic Findings

- Farmers and cooperatives can realize **short-term income** from industrial hemp within a single cropping cycle.
- **Multiple value chains** — textiles, construction (hempcrete), food, biopolymers, and biochar — provide resilience by diversifying revenue streams.

- Local processing hubs create **jobs and entrepreneurship opportunities**, especially in rural areas where alternatives are limited.

4. Financial & Carbon Findings

- Industrial hemp opens pathways to **carbon finance** through durable removals: biochar (hundreds of years of carbon storage) and hemp-lime construction (decades-long storage).
- The voluntary carbon market is expanding rapidly, with **demand for high-integrity removals** priced at USD 100–150 per ton CO_2e.
- CODE HEMP can leverage **blended finance**: grants for pilots, concessional loans for infrastructure, equity for SMEs, and carbon pre-purchases to bridge early liquidity gaps.

5. Social & Inclusion Findings

- Industrial hemp value chains can be structured to **empower women and youth**, two groups often excluded from GGW benefits.
- **Women-led cooperatives** can access new roles in cultivation, processing, and clean cooking energy from pyrolysis by-products.
- Monitoring against the **2X Challenge criteria** ensures that gender inclusion is measured, credible, and impactful.

6. Strategic Findings

- Industrial hemp is **complementary to trees, not a replacement**: it strengthens the GGW by linking restoration to economic and financial sustainability.
- CODE HEMP's **three-step roadmap** (Spain pilot → Ghana demonstrator → Sahel scale-up) provides a structured, replicable model for scaling.
- By aligning with international standards — ICVCM (climate), UNCCD LDN (land), IFAD/World Bank (livelihoods), and 2X Challenge (gender) — the project ensures credibility for donors and investors.

1. Problem Statement & Context

1.1 The Challenge of Desertification

Desertification is not only an ecological phenomenon but also a driver of economic, political, and humanitarian crises. According to the UNCCD Global Land Outlook (2019), up to 24% of the world's land area is degraded, affecting more than 3 billion people. The most vulnerable are those living in drylands, which host 2.1 billion people — nearly half of whom are among the world's poorest.

Every year, an estimated 12 million hectares of productive land are lost, equivalent to the size of Malawi. This represents a loss of USD 42 billion in annual global income, not including indirect costs such as conflict, migration, or health impacts from dust storms.

Africa is disproportionately affected. More than 65% of productive land is degraded, while 280 million Africans live in drylands that are at high risk of desertification. The **Sahel zone** is emblematic: stretching from Senegal to Djibouti, this semi-arid belt is home to over 135 million people, most of whom depend on subsistence farming or pastoralism.

Climate change acts as a multiplier. Projections show that by 2050, average temperatures in the Sahel could rise by 3–5°C, double the global mean. Rainfall variability will increase, with more frequent droughts and extreme weather events. Combined with population growth (Sahelian countries have some of the fastest-growing populations globally, doubling every 20–25 years), this creates a critical pressure point: more people depending on less productive land.

The consequences of desertification are therefore multidimensional:

- **Food security**
  Declining crop yields and livestock productivity threaten nutrition.
- **Water scarcity**
  Reduced rainfall infiltration and aquifer recharge create chronic shortages.
- **Biodiversity loss**
  Natural habitats shrink, reducing ecosystem resilience.
- **Migration**
  Millions are forced to move within or across borders. The World Bank in 2018 estimated that by 2050, 86 million Africans could become internal climate migrants.
- **Conflict**
  Resource competition exacerbates instability, as seen in pastoralist-farmer conflicts in Nigeria, Mali, and Sudan.

Desertification is therefore more than an ecological crisis. It is a development, security, and humanitarian crisis rolled into one. Tackling it requires strategies that address not only ecosystems but also the socio-economic needs of communities that depend on them. In this context, the Sahel has become a testing ground for whether land restoration can stabilize both ecosystems and societies.

1.2 The Great Green Wall Initiative

In 2007, the African Union launched the **Great Green Wall (GGW)** as a flagship continental initiative. Initially framed as a “wall of trees” stretching 8,000 km across 11 countries, its ambition was to serve as a living barrier halting the Sahara’s southward advance. Over time, however, the concept broadened into a **mosaic of land restoration** strategies — including agroforestry, sustainable agriculture, water harvesting, and community-based resource management.

The GGW is part of a global movement toward land restoration, aligned with the Bonn Challenge (restore 350 million hectares by 2030) and the UN Decade on Ecosystem Restoration (2021–2030). Comparisons are often made with China’s “Great Green Wall,” which planted over 66 billion trees since the 1970s, albeit with mixed ecological outcomes.

The current goals are to be achieved by 2030:

- Restore **100 million hectares of degraded land**.
- Sequester **250 million tons of CO_2**.
- Create **10 million green jobs**.

Stakeholders and governance:

- **African Union & Pan-African Agency of the GGW**
  Political leadership, coordination.
- **UNCCD**
  Technical guidance, international visibility.
- **National governments**
  Policy integration, land tenure reforms, enforcement.
- **International donors**
  The EU, World Bank, AfDB, GEF, and bilateral donors (France, Germany, UK) pledged over USD 14 billion in 2021 (One Planet Summit).
- **Civil society & NGOs**
  Organizations like CARE, World Agroforestry Centre, and Oxfam implement projects on the ground.
- **Local communities**
  The ultimate stewards of restored land. Their participation is essential but often underfunded.
- **Private sector**
  Still marginal, though interest is growing in carbon credits, value chains, and sustainable sourcing.

Despite this broad coalition, governance challenges persist. Coordination between actors remains weak, financing is fragmented, and local ownership is often insufficient.

1.3 Current Status (2025)

Eighteen years after its launch, the GGW is widely acknowledged as behind schedule. According to independent reviews, only 18–20 million hectares have been restored, less than one-fifth of the 100 million hectare target.[12]

Achievements:

- Millions of trees were planted, particularly in Ethiopia, Senegal, and Niger.
- Farmer-Managed Natural Regeneration (FMNR) in Niger has restored over 5 million hectares, improving crop yields and fodder availability.
- Increased international visibility: the GGW is now referenced in UNFCCC climate strategies, the EU Green Deal, and numerous donor programs.
- Community successes: women-led cooperatives in Senegal producing gum arabic and baobab oil; farmer cooperatives in Mali practicing sustainable land management.

Gaps and limitations:

1. **Tree mortality**
   Survival rates of seedlings are often below 25% without irrigation. In some projects, >80% losses were reported after three years. Without irrigation, fencing, and long-term care, planted trees frequently fail to establish.
2. **Fragmentation**
   Donor-driven projects operate in silos, with poor cross-country coordination.
3. **Funding vs. disbursement**
   While USD 14 billion has been pledged, much remains undisbursed or tied up in bureaucratic procedures.
4. **Monitoring**
   Inconsistent data collection. “Restored hectares” often count areas treated, not necessarily functional ecosystems.
5. **Community engagement**
   In some cases, projects were top-down, with limited local ownership, leading to abandonment.

- **Community benefit gaps**
  Short-term returns for local people are limited. Without immediate income opportunities, communities are reluctant to invest scarce labor in tree planting that may pay off decades later.

Progress varies between countries. Ethiopia has reported millions of hectares under restoration, but monitoring data are contested. In Niger, community-led farmer-managed natural regeneration has been more successful, yet results remain localized. Overall, momentum exists, but the gap between ambition and reality is widening, as UNCCD President Ibrahim Thiaw noted in 2024: *“The*

[12] Reuters: Exclusive: Africa's Great Green Wall to miss 2030 goal says UN desertification president https://www.reuters.com/business/environment/africas-great-green-wall-miss-2030-goal-says-un-desertification-president-2024-06-12/

Great Green Wall is likely to miss its 2030 target unless faster and more integrated approaches are pursued"[13].

1.4 Why Tree-Only Strategies Are Insufficient

Trees are central to the GGW vision, but their ecological and socio-economic benefits are long-term, often requiring decades to materialize. Trees remain essential for the long-term resilience of Sahelian ecosystems, but relying solely on afforestation has clear limitations:

1. **Time horizon**
   Trees take decades to provide shade, fodder, and ecosystem services, while desertification is advancing now.
2. **Climatic stress**
   Sahelian soils are shallow and poor; temperatures exceed 45°C; rainfall is erratic. Trees require long-term care that is difficult to guarantee.
3. **High risk of failure**
   Seedlings in semi-arid conditions require years of watering and protection from grazing; many projects collapse due to lack of maintenance.
4. **Resource scarcity**
   Establishing tree plantations at scale demands water, fencing, and labor — resources already scarce in vulnerable regions.
5. **Socio-economic mismatch**
   Farmers facing immediate poverty cannot wait decades for trees to mature. Communities need food, fuel, and income today. A promise of benefits in 20 years does not mobilize local ownership.
6. **Ecological mismatch**
   Not all areas are suitable for tree planting; in some degraded soils, trees simply cannot survive without prior soil rehabilitation.

This does not diminish the importance of trees but underlines the need for complementary approaches that can deliver fast results and prepare the ground for tree survival. Farmers need crops and communities need value chains that deliver income within a single season. This gap has left the GGW vulnerable to criticism as a vision disconnected from short-term local realities.

1.5 The Case for Complementary Solutions

To close the gap, GGW needs fast-impact, livelihood-oriented interventions. Such interventions should:

- Stabilize soils within a single season.
- Improve microclimates for tree survival.
- Provide short-term income and jobs.
- Link to carbon markets and global climate finance.

[13] Reuters: Exclusive: Africa's Great Green Wall to miss 2030 goal says UN desertification president https://www.reuters.com/business/environment/africas-great-green-wall-miss-2030-goal-says-un-desertification-president-2024-06-12/

Industrial hemp offers a unique fit:

- **Ecological**
  Deep roots stabilize soil; dense canopy prevents erosion; biomass enriches organic matter; crop suppresses weeds.
- **Water efficiency**
  Requires less irrigation than many alternatives; adaptable to semi-arid climates.
- **Speed**
  Biomass within 3–5 months versus years for trees.
- **Economic diversification**
  Industrial Hemp produces fibers, cellulose, seeds, oils, construction materials (hempcrete), biochar, biocomposites, and biopolymers. It addresses high-value markets in biopolymers and medicinal applications. Potential to generate carbon credits under emerging biochar and biomass methodologies.
- **Carbon potential**
  One hectare can sequester 3–15 tons of CO_2 annually, depending on agronomy, with added long-term storage through hempcrete and biochar[14].
- **Livelihoods**
  Immediate returns through diversified value chains; potential to involve women and youth in processing and entrepreneurship.

This positions hemp not as a replacement, but as a bridge crop: preparing degraded soils for tree planting while generating economic value. In regions like the Sahel, this means industrial hemp can both restore land and restore livelihoods. Communities could see returns within the same year, creating incentives for participation and reducing dependence on donor subsidies.

1.6 Positioning CODE HEMP

CODE HEMP is designed as a proof-of-concept for integrating hemp into the Great Green Wall framework, through a dual-track approach that distinguishes between pilot testing and field demonstration. The dual-track addresses three critical gaps:

- **Ecological gap**
  Fast soil stabilization and fertility improvement where trees cannot survive unaided.
- **Economic gap**
  Short-term income for farmers through diversified value chains.
- **Governance gap**
  Linking restoration efforts to private investment via carbon

Track 1: Spain as Pilot

Spain is a recognized desertification hotspot in the Mediterranean, with vast areas suffering from soil erosion, water scarcity, and biodiversity loss. As an EU member state, it offers a controlled

[14] Portland State University - Institute for Sustainable Solutions: https://www.pdx.edu/sustainability/sites/g/files/znldhr3181/files/2022-09/Industrial%20Hemp%20-%20A%20review%20of%20economic%20potential%20carbon%20sequetration%20and%20bioremediation%20ver16%20August18%202022.pdf

regulatory environment for industrial hemp, access to research infrastructure, and eligibility for European funding instruments. Conducting agronomic trials in Spain allows researchers to test hemp's ecological functions — soil stabilization, water efficiency, biomass yields — under semi-arid conditions that resemble parts of the Sahel, but within a setting of high data reliability and strong institutional support. Spain thus serves as the scientific pilot site to refine methodologies, measure ecological benefits, and build evidence for scaling.

Track 2: Ghana as Demonstrator
Northern Ghana represents a Sahel-relevant African environment facing acute land degradation, erratic rainfall, and rural poverty. Legal reforms passed in 2023 now permit industrial hemp cultivation under strict THC limits, making Ghana one of the first countries in West Africa with a regulatory framework for hemp.

Unlike Spain, Ghana provides the real-world demonstration ground: here, the project can showcase how industrial hemp not only restores soils but also integrates into local economies, creating value chains in textiles, food, construction, biochar, and biocomposites. The demonstrator will focus on farmer engagement, cooperative structures, gender inclusion, and pathways to carbon credit generation.

Both tracks aim to:

1. Demonstrate ecological feasibility.
2. Build value chains for textiles, food, construction, and biochar.
3. Generate carbon credits and attract impact investment.
4. Provide scalable models transferable to other Sahel states.

By combining **Spain as the pilot** and **Ghana as the demonstrator**, CODE HEMP ensures both scientific rigor and contextual relevance. Evidence generated in Spain will refine methodologies, while outcomes in Ghana will prove scalability and socio-economic viability. Together, these pilots can then be transferred across Sahelian countries, embedding industrial hemp as a complementary accelerator within the Great Green Wall.

By doing so, CODE HEMP strengthens the GGW's capacity to deliver on its 2030 targets, while also aligning with the UN Sustainable Development Goals (SDGs) — particularly SDG 13 (Climate Action), SDG 15 (Life on Land), and SDG 8 (Decent Work and Economic Growth).

1.7 Pilot – Demonstrator – Scale Pathway

Spain – Pilot (Controlled Testing)	→	**Ghana – Demonstrator (Real-World Application)**	→	**Sahel – Scale-Up (Replication Across GGW States)**
• Semi-arid Mediterranean hotspot, strong data environment • EU regulatory framework for industrial hemp • Access to research institutions and European climate funding • Focus: agronomic trials, soil stabilization, biomass yields, water efficiency • Output: robust scientific data & methodologies	Knowledge transfer & validated methods	• Northern Ghana: Sahel-relevant degradation & socio-economic stress • Legal reforms (2023) permit industrial hemp under THC limits • Community-focused: farmers, cooperatives, women & youth inclusion • Focus: value chains (textiles, food, construction, biochar, biocomposites), carbon credits • Output: socio-economic viability, policy learning, community ownership	Replication toolkit & investment models	• Adapt methods to 11+ GGW countries • Embed hemp into national GGW action plans • Leverage blended finance: carbon markets, development aid, private investment • Focus: land restoration at scale, climate resilience, regional value chains • Output: accelerated progress toward 100m ha restored, 10m green jobs, 250m t CO_2 sequestered

2. Industrial Hemp as Alternative & Complement

2.1 Hemp's Unique Ecological Profile

Understanding the ecological profile of industrial hemp is essential for assessing its role in land restoration. Unlike many conventional crops, hemp combines biological versatility with environmental resilience, making it a candidate for regions where other plants fail to thrive. It is one of the oldest domesticated plants, historically valued for fiber, seed, and oil, yet its agronomic and ecological potential has only recently been revisited in the context of climate change and land degradation.

Hemp's importance lies not only in what it produces but in how it interacts with its environment. Its deep root systems stabilize soils against erosion, its rapid canopy growth provides immediate ground cover, and its adaptability to diverse climates allows it to perform under conditions of water scarcity. Importantly, hemp does not simply sustain itself — it actively improves the land it grows on by adding organic matter, enhancing soil microbial activity, and increasing water retention.

In restoration contexts such as the Great Green Wall, this ecological profile is critical. Tree seedlings, while indispensable for long-term reforestation, are vulnerable during their early years. Industrial hemp, by contrast, can deliver ecological services within a single season, providing a protective and preparatory role. Its ecological functions — from carbon sequestration to soil enrichment — create synergies with afforestation, positioning hemp as a catalyst crop in land restoration strategies.

What follows is an overview of hemp's most relevant ecological attributes — its roots, growth cycle, water efficiency, carbon storage, and soil-building properties — and how these align with the challenges of desertification.

<u>Root Systems</u>

Hemp develops taproots up to 3 meters deep under favourable conditions. These roots:

- Anchor soils, reducing erosion by wind and water.
- Improve soil porosity, enhancing infiltration and water retention.
- Recycle nutrients from deeper layers, increasing fertility for subsequent crop

<u>Rapid Growth</u>

Industrial hemp is one of the fastest-growing annual plants, reaching 3–4 meters within 120–150 days. This rapid canopy closure provides:

- Immediate ground cover, suppressing weeds.
- A "green shield" protecting soils from erosion.
- Faster biomass accumulation compared to tree seedlings that require years to establish

Minimal Input Requirements

Industrial hemp requires comparatively low fertilizer and water inputs. Studies show it can thrive with 30–50% less water than cotton[15]. Its adaptability to semi-arid conditions makes it suitable for drylands, where water scarcity is the main limiting factor.

Carbon Sequestration

Hemp's fast biomass growth enables high carbon uptake. Conservative estimates suggest 3–15 t CO_2/ha/year, depending on climate and management[16] [17]. Unlike trees, which store carbon mainly in long-lived woody biomass, hemp stores carbon both in:

- Biomass products (textiles, hempcrete, composites), which continue to store carbon throughout their lifecycle.
- Biochar, which locks carbon into soils for centuries.

Soil Improvement:

Hemp contributes organic matter through root residues and leaf litter. Crop rotations including hemp have shown improved soil microbial activity and fertility[18] (Satriani et al., 2021). This is critical in degraded Sahelian soils with depleted organic carbon.

2.2 Complementarity with Trees and Afforestation

Tree planting remains at the heart of the Great Green Wall. Trees provide long-term ecological stability, shade, timber, fodder, and biodiversity habitats. Yet their benefits often materialize only after decades, while communities and ecosystems in the Sahel face urgent challenges today. This time lag creates a tension between the long-term vision of afforestation and the short-term needs of people who live on degraded land. In this context, industrial hemp can be introduced not as a replacement, but as a strategic complement that bridges the temporal gap between immediate needs and long-term ecological restoration.

By growing quickly and improving soil fertility, hemp can prepare degraded land for tree establishment, reduce seedling mortality, and help afforestation projects succeed. It can be intercropped in agroforestry systems or rotated with staple crops, creating a dynamic mosaic of land uses that mirrors the GGW's shift away from a single "wall of trees" towards a more holistic land management strategy. In essence, hemp makes trees more viable by giving them a healthier soil environment and a more patient community that can already derive benefits while waiting for forests to mature.

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[15] Gill, A.R., Loveys, B.R., Cavagnaro, T.R. *et al.* The potential of industrial hemp (*Cannabis sativa* L.) as an emerging drought resistant fibre crop. *Plant Soil* 493, 7–16 (2023). https://doi.org/10.1007/s11104-023-06219-9

[16] Ahmed ATMF, Islam MZ, Mahmud MS, Sarker ME, Islam MR. Hemp as a potential raw material toward a sustainable world: A review. Heliyon. 2022 Jan 13;8(1):e08753. doi: 10.1016/j.heliyon.2022.e08753: https://www.cell.com/heliyon/fulltext/S2405-8440%2822%2900041-X

[17] Portland State University - Institute for Sustainable Solutions: https://www.pdx.edu/sustainability/sites/g/files/znldhr3181/files/2022-09/Industrial%20Hemp%20-%20A%20review%20of%20economic%20potential%20carbon%20sequetration%20and%20bioremediation%20ver16%20August18%202022.pdf

[18] Satriani, Antonio, Antonio Loperte, and Simone Pascucci. 2021. "The Cultivation of Industrial Hemp as Alternative Crop in a Less-Favoured Agricultural Area in Southern Italy: The Pignola Case Study" *Pollutants* 1, no. 3: 169-180. https://doi.org/10.3390/pollutants1030014

Industrial hemp is not a substitute for trees — it is a **catalyst and complement**:

- **Short-term vs. long-term benefits**
  Hemp delivers soil stabilization, biomass, and income in months, while trees provide shade, timber, and ecosystem services in decades.
- **Bridge crop role**
  By improving soil organic matter and water retention, hemp creates micro-environments that increase tree survival rates.
- **Agroforestry integration**
  Hemp can be integrated into agroforestry systems, planted in rotation or between tree rows to provide immediate cover and revenue.
- **Landscape mosaics**
  GGW already embraces a mosaic approach; hemp fits as a fast-growing annual layer within this mosaic.

Evidence from China's Great Green Wall suggests that monoculture afforestation can fail if soils are not prepared. Hemp avoids such pitfalls by restoring soils first, then enabling trees.

2.3 Economic Dimensions of Hemp Integration

Land restoration will not succeed if it is seen purely as an ecological exercise. For communities in the Sahel, where poverty rates are among the highest in the world, restoration must also deliver **economic value**. Farmers and pastoralists must be able to support their families while engaging in long-term land stewardship. Without this, restoration risks being abandoned once donor funding ends.

Industrial hemp is uniquely positioned to fill this gap. Unlike many restoration crops that deliver only ecological benefits, hemp opens **diverse value chains** with both local and global demand. Textiles, food, construction, composites, and biochar represent industries that can transform restored landscapes into hubs of sustainable economic activity. Hemp also connects directly to emerging green markets, such as carbon credits and climate finance, creating pathways for investment that traditional crops cannot access.

By generating revenue streams in months, hemp ensures that restoration is not only a cost to be borne but an opportunity to be seized. This transforms the narrative of the GGW: from a donor-driven initiative to a self-sustaining economic transformation engine. The GGW is not only an ecological project but also a livelihood strategy. Hemp's value chains offer unique diversification potential:

- **Textiles and Fibers**
  Hemp fiber is durable, biodegradable, and increasingly in demand as a sustainable alternative to cotton and synthetics. With global hemp textile markets projected to exceed USD 10 billion by 2030[19], African producers could capture niche export markets.

[19] Grand View Research (2023). *Industrial Hemp Market Size, Share & Trends Report.* https://www.grandviewresearch.com/industry-analysis/industrial-hemp-market

- **Construction (Hempcrete, Panels)**
  Hemp shiv mixed with lime forms hempcrete, a carbon-negative material with rising global demand. Construction markets in West Africa offer strong domestic potential.
- **Food and Oil**
  Hemp seeds contain 30–35% oil and are rich in protein and essential fatty acids. They can support local nutrition while feeding into global health-food markets.
- **Biochar and Biocomposites**
  Hemp biomass can be pyrolyzed into biochar, stabilizing carbon and improving soils. Hemp fibers and hurds are increasingly used in automotive and packaging composites.
- **Carbon Credits**
  With proper methodologies, hemp cultivation could generate credits through sequestration (biomass, biochar, hempcrete). This links GGW to climate finance streams such as the Green Climate Fund and voluntary carbon markets.

By comparison, tree planting provides limited short-term revenues; hemp creates **immediate value chains** that sustain community interest in land restoration.

2.4 Social and Community Benefits

Restoration must be socially embedded. The Great Green Wall is not just about planting trees or crops; it is about securing the livelihoods, dignity, and resilience of millions of people. If restoration does not translate into immediate and visible benefits for rural households, it will fail to mobilize the local ownership that is critical for long-term success.

Industrial hemp offers tangible social benefits that respond directly to this challenge. By diversifying incomes, it reduces the vulnerability of smallholder farmers to drought or market shocks. By creating jobs along the processing chain, it offers alternatives to youth unemployment and migration. Women, who are often marginalized in rural economies, can be empowered through roles in seed processing, textile production, or small-scale food enterprises. Beyond income, hemp cultivation can serve as a platform for **education and skills transfer**, linking rural communities with universities, NGOs, and training programs.

Thus, hemp does not only restore land — it restores hope and agency in communities that have often been sidelined in top-down development programs.

The integration of hemp can directly address GGW's social challenges:

- **Income Diversification**
  Industrial hemp reduces dependency on single subsistence crops. Farmers can combine hemp with staple grains, improving resilience against climate shocks and yield per hectare.
- **Employment Generation**
  Industrial hemp cultivation, processing, and product development create rural jobs, particularly in regions with high youth unemployment.
- **Women's Empowerment**
  Women can play leading roles in seed processing, textiles, and food value chains. Experience from Senegalese cooperatives (e.g., baobab and shea) shows that women-led enterprises succeed when linked to global value chains.

- **Education and Skills**
  Introducing hemp requires training in cultivation, processing, and product innovation. Partnerships with local universities and vocational schools can embed new skills.
- **Health and Nutrition**
  Industrial hemp seeds are rich in protein and essential fatty acids, offering nutritional benefits in malnourished regions and deliver huge varieties of amino acids for nutrition and medical purposes.

Hemp therefore strengthens the social contract around land restoration: communities see tangible, short-term benefits, increasing ownership and reducing project abandonment.

2.5 Policy and Governance Dimensions

For industrial hemp to fulfill its potential, it must be embedded in supportive policy and governance frameworks. The Great Green Wall is already a highly political project, involving multiple governments, international donors, and civil society actors. Adding hemp to this portfolio requires clear legal frameworks, careful communication, and proactive engagement to overcome stigma and misconceptions.

At the global level, industrial hemp fits naturally within the

UN Sustainable Development Goals (SDGs)

- SDG 13 (Climate Action): CO_2 sequestration and resilience.
- SDG 15 (Life on Land): Combat desertification and restore ecosystems.
- SDG 8 (Decent Work and Economic Growth): Jobs and value chains.

Paris Agreement & NDCs
Hemp cultivation contributes to mitigation targets; countries can include it in their Nationally Determined Contributions (NDCs).

African Union Agenda 2063
Supports sustainable industrialization and youth employment.

European Green Deal
EU support for climate-friendly crops could fund Spanish pilots, with transfer of knowledge to Africa.

At the national level, reforms are emerging as industrial hemp integration aligns with international frameworks:

Legal frameworks are evolving:

- **EU**
  Hemp cultivation permitted if THC < 0.3%.
- **Ghana**
  Legal reforms in 2023 permit industrial hemp under THC limits

- **Other African states**
  Nigeria, Morocco, South Africa are exploring regulatory reforms.

These examples demonstrate a clear momentum towards normalization of hemp as a strategic crop. Yet governance challenges remain: licensing systems must be transparent; public education campaigns must clarify that hemp is non-psychoactive; and integration into national climate strategies must be explicit. Done right, hemp can become a politically acceptable and institutionally supported tool for restoration. Done poorly, it risks being sidelined by legal ambiguity or social resistance.

2.6 Risks and Limitations

No innovation is risk-free. Industrial hemp, like any crop, has limitations that must be acknowledged honestly. Ecologically, it requires sufficient water to establish; in hyper-arid zones, it may struggle without irrigation. Economically, global hemp markets are still volatile, with supply surges sometimes depressing prices. Politically, cannabis stigma can slow regulatory reforms or create confusion among communities. Socially, there is a risk that hemp could be perceived as competing with food crops for land if not carefully integrated.

Recognizing these risks is not a weakness but a strength. By planning proactively — through careful site selection, diversified markets, policy engagement, and strong communication — these risks can be mitigated. For example, pairing hemp with food crops in rotation prevents competition, while framing hemp as a “soil restorer” in national policies builds legitimacy. Acknowledging challenges upfront makes CODE HEMP a credible initiative that is both visionary and realistic.

Key considerations:

- **Climatic limits**
  Extreme arid zones may still be unsuitable for hemp; irrigation may be needed in establishment.
- **Market volatility**
  Global hemp markets are growing but subject to oversupply and regulatory shifts.
- **Policy risk**
  Industrial hemp reforms can face political or cultural resistance.
- **Knowledge gaps**
  Limited research on hemp performance under African dryland conditions.
- **Competition for land**
  Hemp must complement, not displace, food crops.

Mitigation strategies include phased pilots, diversified markets, and policy engagement with local communities and governments.

2.7 Industrial Hemp as Catalyst, Not Competitor

The Great Green Wall is one of the most ambitious restoration projects in human history. But ambition alone will not restore 100 million hectares or create 10 million jobs. The GGW needs tools

that deliver both speed and sustainability, both ecological and economic results. Hemp offers precisely this dual impact.

- As a **catalyst**, industrial hemp accelerates ecological recovery by stabilizing soils, adding organic matter, and creating microclimates for trees.
- As an **economic driver**, it creates diversified income streams, jobs, and investment opportunities that make restoration attractive to communities.
- Hemp does not replace trees — it **prepares the ground for them** and keeps communities engaged until long-term afforestation benefits arrive. In this sense, hemp is not only a plant but a **strategic lever.**

It bridges the gap between immediate needs and long-term goals, between ecological restoration and economic development, between donor funding and self-sustaining value chains. Positioned as an **alternative and complement**, hemp can help transform the Great Green Wall from a fragmented dream into a viable reality. It can **unlock the Great Green Wall's potential** by filling its two main gaps:

1. **Immediate ecological impact**
   soil stabilization, biomass, water retention.
2. **Immediate socio-economic impact**
   diversified value chains, jobs, carbon credits.

By serving as a bridge crop, industrial hemp enables degraded soils to recover faster, improves tree survival rates, and provides communities with livelihoods. This **dual benefit** — ecological and economic — is precisely what the GGW needs to accelerate progress toward its 2030 targets.

2.8 Comparative Overview: Trees vs. Hemp vs. Mixed Strategies

Dimension	Tree-Based Strategies	Hemp-Based Strategies	Mixed Strategy (Trees + Hemp)
Time to Impact	Long-term (10–20+ years for full ecological and economic benefits).	Very short-term (3–5 months for ecological cover and income).	Short-term stabilization from hemp + long-term resilience from trees.
Ecological Benefits	Biodiversity habitat, carbon sequestration over decades, shade, timber, fodder.	Rapid soil stabilization, erosion control, humus formation, water retention, annual carbon sequestration (3–15 t CO_2/ha/year).	Immediate soil protection and fertility from hemp enhances tree survival and ecosystem establishment.
Carbon Sequestration	High potential, but delayed; depends on tree survival (often <25% in arid zones).	Fast uptake but lower per plant; long-term storage through hempcrete, composites, biochar.	Combination maximizes both speed (hemp) and permanence (trees).
Soil Health	Improves slowly via litter and root systems; requires tree survival.	Rapid improvement through biomass, root penetration, microbial activity.	Hemp prepares soil for trees; trees maintain long-term fertility.
Water Requirements	High during establishment; seedlings	Relatively low; hemp adapts to semi-arid climates, needs	Hemp reduces evaporation and enhances water

	vulnerable to drought.	less irrigation than cotton/maize.	retention for tree growth.
Economic Value Chains	Limited in short term; timber, gum, fruit, or fodder emerge after years.	Diverse and immediate: textiles, food, oil, construction (hempcrete), biochar, biocomposites, biopolymers.	Hemp provides early income; trees later add higher-value products.
Community Benefits	Jobs mainly in planting and maintenance; benefits are delayed.	Immediate employment in farming, processing, value chains; supports women/youth enterprises.	Early jobs from hemp sustain interest until tree-based jobs and products arrive.
Risk Factors	High mortality rates; long care needed; vulnerable to climate extremes.	Market volatility; policy stigma; not viable in hyper-arid zones without water support.	Diversifies risks: ecological (trees) + economic (hemp).
Policy Fit	Central to GGW narrative but struggling in practice.	Emerging legitimacy; requires legal reforms, awareness campaigns.	Integrates into GGW as “complementary accelerator,” aligning with SDGs and AU Agenda 2063.

Key Takeaways

- Relying on **trees alone** provides crucial long-term ecological services such as biodiversity habitats, carbon storage, and shade, but the benefits take decades to materialize. High seedling mortality and the lack of short-term incentives make it difficult for communities to stay engaged.
- Depending on **hemp alone** offers rapid results: within a single season, soils are stabilized, erosion is reduced, and communities gain immediate income through diverse value chains. However, hemp lacks the long-term permanence of trees and cannot fully substitute their ecological role.
- A **mixed strategy** that combines trees and hemp leverages the strengths of both. Hemp delivers speed by preparing soils and creating short-term economic benefits, while trees secure sustainability through long-term ecosystem services. This integrated approach provides the only realistic pathway to achieving the Great Green Wall’s ambitious goals of restoring land, sequestering carbon, and supporting livelihoods.

3. Feasibility & Case

3.1 Rationale for Regional Selection

Demonstrating feasibility is not just a scientific exercise; it is also about building credibility, political legitimacy, and investor confidence. For industrial hemp to be accepted as part of the Great Green Wall portfolio, decision-makers require evidence from both controlled environments and real-world applications. A purely European pilot might be dismissed as irrelevant to African realities, while a solely African demonstration without rigorous data could fail to convince international investors.

For this reason, CODE HEMP proposes a dual-track feasibility design:

- **Spain as a pilot site**, where research institutions, policy frameworks, and monitoring capacities allow for precise measurement of hemp's ecological performance. Spain's desertification crisis provides ecological relevance, while the EU's regulatory clarity and climate funding streams provide institutional support.
- **Ghana as a demonstrator site**, where ecological stress, poverty, and socio-economic realities mirror the challenges of the Sahel. Ghana's recent legal reforms and vibrant civil society create the space to test hemp as a livelihood strategy, not just an agronomic experiment.

This pilot–demonstrator model ensures that CODE HEMP generates both the hard data needed to publish in peer-reviewed journals and the real-world stories that inspire policymakers and communities. By combining these two contexts, the project demonstrates that hemp is not merely a theoretical solution, but a practical, adaptable, and transferable tool for land restoration.

3.2 Spain – Pilot Region

Spain is widely recognized as one of the European countries most affected by desertification. The combination of overexploited water resources, intensive monocultures, soil erosion, and rising temperatures has placed more than two-thirds of its territory at risk. This makes Spain a critical test environment for crops and land management strategies that can withstand semi-arid stress. Unlike many African countries, Spain also offers a robust research and policy ecosystem: it is embedded in the EU's agricultural and environmental frameworks, hosts world-class universities and agricultural institutes, and has access to European climate and innovation funds.

For CODE HEMP, Spain represents the ideal pilot environment. Here, industrial hemp can be tested under controlled yet challenging conditions, where monitoring and data collection are reliable, and results can be translated into scientifically validated benchmarks. These benchmarks will not only strengthen the case for industrial hemp within Europe but also create transferable methodologies for African contexts. Spain thus provides the scientific backbone for CODE HEMP's feasibility agenda.

Context

Spain is one of the most desertification-prone countries in Europe. Over **70% of Spanish territory is vulnerable to desertification**, particularly in the south and east (Murcia, Andalusia, Valencia). Intensive agriculture, over-extraction of groundwater, and climate change-induced droughts have

degraded soils and aquifers. This makes Spain an ideal European testbed for industrial hemp cultivation under semi-arid conditions.

Ecological Feasibility

- Industrial hemp thrives in Mediterranean climates with sufficient spring rainfall or supplementary irrigation.
- Deep root systems counteract erosion on sloped and overgrazed lands.
- Hemp requires fewer pesticides than conventional crops (cotton, maize), reducing chemical load on fragile soils.
- Spanish soils degraded by intensive monocultures (e.g., olives, citrus) could benefit from hemp rotations that restore organic carbon and microbial life.

Economic & Policy Environment

- EU legislation permits hemp cultivation with <0.3% THC, creating a clear regulatory framework.
- Spain has a history of hemp cultivation (e.g., Catalonia) and is experiencing renewed interest, particularly for CBD and industrial applications.
- Significant foreign investment (Canada, US, UK) in Spanish hemp sector demonstrates market attractiveness.
- EU Green Deal and Horizon Europe provide funding streams for sustainable crops and bio-based materials.

Role in CODE HEMP

Spain serves as the **scientific pilot**:

- Controlled agronomic trials on degraded soils.
- Quantification of ecological benefits (CO_2 sequestration, water retention, soil fertility).
- Development of metrics and methodologies for carbon crediting (biochar, hempcrete).
- Partnerships with universities, research institutes, and private investors.

Output

Validated data and methodologies to strengthen the scientific case for African applications.

3.3 Ghana – Demonstrator Region

Ghana offers a very different but equally strategic environment. While not part of the Sahel's core belt, its northern savannah regions face challenges that mirror Sahelian conditions: erratic rainfall, declining soil fertility, high vulnerability to climate shocks, and widespread poverty. At the same time, Ghana is politically stable compared to some Sahelian neighbours, has an emerging legal framework for industrial hemp cultivation, and a strong network of universities, NGOs, and international donors already engaged in agricultural innovation.

For CODE HEMP, Ghana serves as the demonstrator site: the place where theory meets practice in Africa. Unlike Spain, where research is the primary output, Ghana focuses on community engagement, livelihood creation, and policy integration. By demonstrating industrial hemp cultivation in partnership with farmers, cooperatives, and local institutions, CODE HEMP can showcase how industrial hemp delivers tangible benefits in a real-world African setting. Success in

Ghana provides not just technical proof, but also the social license to operate across the wider Sahel.

Context

Northern Ghana faces growing pressures from desertification. Rainfall has become increasingly erratic, droughts more frequent, and land degradation severe. Agriculture employs over 38% of the labour force, yet productivity is low, and poverty rates remain high: in the Northern Savannah Region, multidimensional poverty is recorded the highest (76.6%) in Ghana in 2023 with more than a third percentage points (35.3%) higher than the national average[20].

Ghana is not part of the Sahel proper, but its northern savannah mirrors Sahelian challenges — degraded soils, water scarcity, subsistence farming, and youth unemployment. This makes it an ideal demonstration site for Sahel-relevant restoration.

Legal Environment

- The 2020 Narcotics Control Commission Bill allowed cultivation of low-THC cannabis, but only in 2023 was industrial hemp cultivation formally legalized.
- Licenses can now be granted by the Interior Minister under strict THC (<0.3%) thresholds
- Ghana thus offers a legal and political opening for industrial hemp, positioning it as one of Africa's pioneers.

Ecological Feasibility

- Hemp can stabilize fragile soils in the Northern Region, improving water retention and reducing erosion.
- Crop residues and biochar can enrich depleted soils, boosting subsequent maize and millet harvests.
- Hemp's adaptability to erratic rainfall makes it more resilient than cotton or maize monocultures.

Economic & Social Feasibility

- Value chain opportunities:
    - Hemp textiles (local production + export markets).
    - Hempcrete for low-cost sustainable housing.
    - Biochar for soil fertility and carbon credits.
    - Seeds and oil for nutrition.
- Employment: processing, transport, and value addition can create jobs for youth and women.
- Education: partnerships with universities (e.g., Tamale Technical University - Department of Agricultural Engineering, Kwame Nkrumah University of Science and Technology - College of Agriculture and Natural Resources, University of Ghana - School of Agriculture and other agricultural colleges) for R&D and training

[20] Ghana Statistical Service: Multidimensional Poverty - 2023 Quarter 4 Bulletin, June 2024: https://www.statsghana.gov.gh/gssmain/storage/img/infobank/2023_Q1-Q4_MPI_Report_Bulletin.pdf

Role in CODE HEMP

Ghana serves as the **real-world demonstrator**:

- Implementation of community-based hemp cultivation.
- Testing of cooperative and PPP models.
- Building of local processing units and value chains.
- Engagement with regulators, NGOs, and international investors.

Output

Demonstration of socio-economic viability and community ownership in an African context.

3.4 Comparative SWOT Analysis

To better understand feasibility, it is not enough to describe Spain and Ghana individually. A comparative analysis helps identify where strengths can be leveraged, where weaknesses must be mitigated, and how opportunities and threats differ between a European and African context.

This matters because investors, donors, and governments will ask:

Why Spain?
Why Ghana?
And how do they complement each other?

A SWOT analysis provides a structured way to address these questions. It highlights that Spain offers regulatory stability, funding, and scientific infrastructure, but faces high land costs and CBD market saturation. Ghana, by contrast, offers urgent ecological and social needs and a pioneering legal framework, but lacks infrastructure and remains vulnerable to policy uncertainty.

By mapping these factors, CODE HEMP demonstrates that neither site alone is sufficient, but together they provide a holistic feasibility framework.

Spain (Pilot)	**Strengths:** Strong research environment, EU regulatory clarity, funding access, investor interest.	**Weaknesses:** High land costs, competition with CBD-focused cultivation, fragmented national regulations.
	Opportunities: EU Green Deal, Horizon Europe, carbon credit methodologies, export markets.	**Threats:** Market volatility (CBD oversupply), public scepticism over cannabis.

Ghana (Demonstrator)	**Strengths:** Legal reforms, Sahel-relevant climate, urgent need for restoration, low-cost labour.	**Weaknesses:** Limited infrastructure, nascent regulatory environment, stigma around cannabis.
	Opportunities: Poverty reduction, youth employment, carbon finance, African leadership in hemp.	**Threats:** Political instability, policy reversals, illegal cannabis overshadowing industrial hemp.

3.5 Transferability and Scaling

The ultimate test of feasibility is not success in one or two locations, but whether lessons can be scaled and adapted across diverse contexts. The Great Green Wall spans over 8,000 kilometers, cutting across 11 core countries and involving more than 20 African states in some form. Each has different ecological conditions, governance systems, and socio-economic realities.

Therefore, CODE HEMP's dual-track approach is designed from the outset with transferability in mind. Spain provides transferable scientific data and methodologies that can be standardized, published, and replicated. Ghana provides the demonstrator of social, political, and market realities in Africa. Together, these pilots feed into a replication toolkit — a package of agronomic guidelines, policy recommendations, and business models that can be adapted to Sahelian states from Senegal to Ethiopia.

This transferability is not only regional. Lessons from Spain and Ghana could also inform land restoration initiatives in North Africa (Morocco, Tunisia), Central Asia (Kazakhstan, Uzbekistan), and South America (NE Brazil), all regions facing similar desertification challenges. In this sense, CODE HEMP positions industrial hemp not as a niche experiment, but as a **globally relevant restoration tool**.

3.6 Conclusion: Feasibility as Foundation for Scale

Feasibility analysis is more than a checklist of agronomic potential; it is the foundation for legitimacy, scale, and investment. Without feasibility, industrial hemp remains an interesting idea. With feasibility, industrial hemp becomes a credible, fundable, and replicable solution for one of the world's most urgent ecological challenges.

Spain and Ghana together embody the necessary duality:

- **Spain as the pilot** proves that industrial hemp works under controlled, measurable conditions. It generates robust ecological and carbon data, builds investor trust, and secures EU-level political support.
- **Ghana as the demonstrator** shows that industrial hemp is not only scientifically sound but socially viable. It integrates with community livelihoods, operates within African regulatory frameworks, and produces tangible economic benefits in contexts of poverty and land degradation.

By combining these two sites, CODE HEMP creates a **North–South bridge**: Europe provides scientific validation and funding, Africa provides real-world demonstration and socio-economic impact. This partnership model strengthens both continents and aligns with broader agendas such as the African Union Agenda 2063, the UN SDGs, and the European Green Deal.

The conclusion is clear: feasibility is not an abstract exercise. It is the gateway to scale. Spain and Ghana are not end points but stepping stones toward embedding industrial hemp into the Great Green Wall's toolkit. From there, replication across the Sahel can accelerate restoration, create millions of jobs, and unlock new forms of climate finance. Industrial hemp, tested and proven in diverse settings, becomes not only feasible but inevitable as part of the solution.

4. Economic Opportunities

4.1 Why Economics Matter for the GGW

The Great Green Wall is often framed as an environmental project, but at its heart it is an economic transformation agenda. Land restoration will not endure unless it delivers tangible benefits to farmers, communities, and governments. Donor-driven tree planting alone cannot sustain momentum; restoration must create jobs, markets, and profits. This is why CODE HEMP places economic feasibility at the center of its vision. Hemp's unique advantage is that it provides ecological services and generates cash flow in the same season, creating incentives that align ecological goals with economic realities.

The Great Green Wall will only scale if restoration earns — for smallholders, for local enterprises, and for capital providers. Industrial hemp is one of the few restoration crops that can generate cash flow within a season, create value-added industries (textiles, construction, food, composites), and unlock carbon finance — all while improving soils that later support trees. Global and European demand signals are moving in the right direction (industrial hemp market ~USD 5.5bn in 2023, projected ~USD 16.8bn by 2030), indicating that if we can organize reliable supply and quality, markets exist to absorb scaled production.

4.2 Market Outlook: Where the Demand Comes From

Any investor or policymaker will ask: *where will the demand come from?* Without markets, restoration crops remain donor-dependent. Industrial hemp, by contrast, is already supported by structural global, European, and African demand drivers. From eco-fashion to sustainable construction, from protein-rich foods to premium carbon credits, industrial hemp feeds into sectors experiencing rapid growth. At the same time, regulatory developments in Europe (2024) and Africa (2023) signal a more stable policy environment. This section outlines the most recent (2024–2025) market signals that position industrial hemp as a viable growth industry.

4.2.1 Global signals

- In 2023, carbon pricing revenues worldwide reached a record USD 104 billion, per the *State and Trends of Carbon Pricing 2024* report[21].
- The voluntary carbon markets and removal credit segments continue to evolve; premium removal credits (e.g. biochar) are increasingly commanding high prices in institutional offtake contracts[22].
- Emissions Trading Systems (ETS) remain a major backbone: for example, the EU ETS continues to be a reference carbon market, with increased scrutiny on supply, auctioning, and price stability through 2024[23].

[21] https://www.worldbank.org/en/news/press-release/2024/05/21/global-carbon-pricing-revenues-top-a-record-100-billion
[22] Carbon Market Watch, Annual Report 2024: https://carbonmarketwatch.org/publications/annual-report-2024/
[23] European Commission, DG for Climate Action, 2024 Carbon Market Report: https://climate.ec.europa.eu/news-your-voice/news/2024-carbon-market-report-stable-and-well-functioning-market-driving-emissions-power-and-industry-2024-11-19_en

- The global carbon removal market is projected to expand dramatically, with some forecasts estimating it could reach USD 100 billion per year by 2030–2035 under favorable conditions[24].

4.2.2 Europe & Hemp Market Developments

- In 2024, the European Commission recorded 116 hemp varieties now registered in the EU catalogue, reflecting a maturing regulatory environment.
- Since 2023 the European Commission explicitly confirms CAP eligibility for hemp varieties ≤ 0.3% THC
- A new EU regulation — Commission Implementing Regulation (EU) 2024/2391 — introduced reporting obligations for hemp producers to improve market transparency and alignment with other fiber crops (flax, cotton).
- The European Industrial Hemp Association (EIHA) cites updated cost estimates: producing hemp fiber now costs between €800 and €1,200 per ton, depending on scale, machinery, and location[25].
- According to the *Alliance Flax-Linen & Hemp Economic Observatory*, the 2024 European hemp/fiber harvest saw recorded cultivation area and yields, though prices experienced correction toward the end of the year[26].
- The hemp sector in Europe is still grappling with supply chain bottlenecks: only a small number of decortication facilities exist, and many farmers export raw stalks rather than processed fiber.

4.2.3 Africa & Structural Demand Drivers

In Africa, demand drivers such as affordable housing, infrastructure expansion, and sustainable construction strongly favor low-carbon building materials (hempcrete, insulation). IFC projects the housing shortfall (51 million units now, rising toward 130 million by 2030) as a structural market pull[27].

Several African governments and development banks are increasing support for green materials and circular economy strategies, opening policy windows for hemp-based building and bioproducts. (While not all data is yet publicly tabulated for 2024/2025, this trend is evident in emerging national strategies.)

4.3 Value Chains & Unit Economics

Hemp's advantage is that nearly every component of the plant has value. This diversity creates stacked revenues per hectare and buffers farmers and investors against volatility in any single market. Beyond fiber, seeds, shiv, and biochar, hemp's cellulose-rich stalks are emerging as a

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[24] https://www.reuters.com/sustainability/climate-energy/global-carbon-removal-market-could-reach-100-billionyr-2030-35-report-says-2024-06-27/

[25] Marius Michels, Adrian Brinkmann, Oliver Mußhoff, Economic, ecological and social perspectives of industrial hemp cultivation in Germany: A qualitative analysis, Journal of Environmental Management, Volume 389, 2025, https://doi.org/10.1016/j.jenvman.2025.126117

[26] https://allianceflaxlinenhemp.eu/en/flax-linen-hemp-economic-observatory

[27] International Finance Corporation, IFC Scaling Housing Finance in Africa: https://www.ifc.org/content/dam/ifc/doc/2024/scaling-housing-finance-in-africa-factsheet.pdf

strategic raw material for packaging and biopolymer industries. With governments tightening restrictions on single-use plastics and corporates racing to decarbonize packaging, hemp cellulose adds a new high-potential revenue stream.

4.3.1 Fiber & Shiv (Construction, Insulation, Composites)

Hemp fiber is one of the world's strongest natural fibers, prized for its tensile strength, durability, and low environmental footprint. Its co-product, shiv (the woody core), is increasingly valuable in the construction industry.

- **Yields**
  4–7.5 t/ha of fiber and shiv under EU conditions.
- **Applications**
  - Textiles (clothing, eco-fashion, technical fabrics).
  - Insulation materials (sound-absorbing, breathable panels).
  - Hempcrete (mixing shiv with lime for walls and blocks).
  - Automotive composites (door panels, dashboards, insulation mats).
- **Market drivers**
  - Construction sector's decarbonization targets.
  - EU legislation (Energy Performance of Buildings Directive) creating demand for sustainable insulation.
  - Automotive OEMs committing to natural fibers for lightweighting.
- **Revenue potential**
  Fiber-based products fetch USD 1,000–1,200/t; hempcrete blocks command premiums in green building markets.

4.3.2 Seeds & Food

Industrial hemp seeds are a nutritional powerhouse, containing complete proteins, essential fatty acids (Omega-3, 6, 9), and vital minerals. Unlike many crops, industrial hemp seeds serve both local nutrition and export health markets, making them a dual-purpose income stream.

- **Yields**
  0.6–1.2 t/ha of seeds; oil content 28–35%.
- **Applications**
  - Oil (culinary, cosmetics, nutraceuticals).
  - Protein flour (sports nutrition, bakery, plant-based foods).
  - Animal feed (high-protein seedcake after oil extraction).
- **Market drivers**
  - Rising global plant-protein demand.
  - Growing vegan/vegetarian consumer base.
  - African malnutrition rates create local demand for nutrient-dense foods.
- **Revenue potential**
  Industrial hemp seed oil retails at USD 10–15/litre in EU health markets; protein flour USD 5–8/kg.

4.3.3 Biochar (Soil Input & Carbon Removals)

Turning industrial hemp residues into biochar through pyrolysis unlocks multiple streams of value: durable carbon removal, improved soil fertility, and energy co-products. This makes pyrolysis one of the most attractive processing options in terms of both climate impact and local utility.

- **Yields**
  3–5 t/ha dry residues → 0.8–1.8 t biochar (depending on process efficiency).
- **Applications**
  - Soil conditioner: enhances fertility, water retention, and microbial activity.
  - Animal feed additive: improves digestion, reduces methane emissions.
  - Carbon credits: recognized as durable removals, with premium prices in voluntary markets.
  - Pyrolysis gas (syngas): A combustible gas mixture (mainly H_2, CO, CH_4) produced during pyrolysis.
    - Can be used for cooking fuel at the community level, reducing reliance on unsustainable firewood.
    - Can power electricity generation (small-scale gas engines or turbines), supporting rural electrification.
  - Bio-oil**:** A liquid by-product that can be refined into heating fuel or industrial inputs.
- **Market drivers**
  - Strong demand for durable carbon credits (USD 100–150/tCO_2e) in premium voluntary markets.
  - Global push for clean cooking solutions (aligned with SDG 7: Affordable and Clean Energy).
  - Rising demand for decentralized renewable energy in Africa, where 600 million people lack electricity access.
- **Revenue potential**
  - Carbon credits generate high-margin returns.
  - Biochar sales as soil inputs add cash flow.
  - Syngas and bio-oil can displace expensive or unsustainable fuels, reducing OPEX for communities and creating new micro-enterprises (cooking fuel distribution, small power grids).

4.3.4 Biocomposites & Biopolymers

The global shift away from fossil-based plastics is creating a surge in demand for bio-based composites. Hemp fibers and shiv can be blended into polymers to create lightweight, high-strength materials for the automotive, construction, and packaging industries.

- **Yields**
  Mass balance from stalks ~300 kg bast fiber and ~600 kg shiv per 1,000 kg of dry stalk
- **Applications**
  - Automotive composites (BMW, Mercedes, and Audi already use hemp fiber components).
  - Packaging materials (biodegradable trays, films).
  - Consumer goods (sports equipment, furniture, electronics casings).

- **Market drivers**
  - EU directives banning single-use plastics.
  - Corporate ESG commitments (FMCGs pledging 100% recyclable/biodegradable packaging by 2030).
  - Automotive lightweighting to improve fuel efficiency and EV range.
- **Revenue potential**
  Natural fiber composites priced at USD 1,500–2,000/t; premium automotive-grade products or preliminary products, semi-finished products for the space industry even higher.

4.3.5 Cellulose (Packaging, Bioplastics, Nanomaterials)

Industrial hemp stalks are 60–70% cellulose, making them an abundant resource for packaging, paper, and advanced biopolymers. With governments phasing out fossil plastics and companies racing for sustainable alternatives, hemp cellulose is a high-potential growth area.

- **Yield**
  Hemp stalks contain 60–70% cellulose. Hurds: ~44–45% α-cellulose (with hemicellulose 20–25%, lignin 20–25%). Pulping yields exceed hardwood in some trials; blending 25% hemp with hardwood raised pulp yield by ~4%. Nanocellulose conversion typically ~10–20% of pulp.
- **Applications**:
  - Packaging & Paper: premium specialty papers, cardboard, recyclable food packaging.
  - Bioplastics & Films: hemp-derived cellulose acetate for compostable plastics.
  - Nanocellulose: advanced materials for barrier films, medical uses, and composites.
- **Market drivers**
  - EU Single-Use Plastics Directive (2019/904).
  - Global packaging industry (~USD 1 trillion) undergoing a green transition.
  - Consumer demand for biodegradable, recyclable packaging.
- **Revenue potential**
  Hemp cellulose pulp sells for USD 600–1,200/t; nanocellulose derivatives achieve much higher margins.

4.4 Processing & Logistics

The economic viability of hemp does not depend solely on cultivation. It is the processing and logistics infrastructure that turns raw stalks and seeds into market-ready products. Many hemp initiatives have failed not because the crop underperforms, but because processing facilities are absent or too centralized. For the Great Green Wall context, success requires a decentralized yet connected processing model, where **village-level units** feed into regional hubs, and hubs are linked to export or industrial partners.

Industrial hemp's value is unlocked in the processing chain, not the field. By combining high-tech centralized pilots (Spain) with low-tech decentralized hubs (Ghana), CODE HEMP demonstrates how to build a **resilient, inclusive, and profitable industrial hemp economy**. Energy co-products from pyrolysis further strengthen the model, making it both economically attractive and socially transformative.

4.4.1 The Processing Chain

Industrial hemp undergoes several stages before it enters value chains:

1. **Harvesting & Retting**
   After 90–120 days, hemp is cut and left in the field for retting (dew or water), which separates fibers by microbial action. Controlled enzymatic retting is possible but costly.
2. **Decortication**
   Specialized machinery separates bast fibers (outer layer) from shiv/hurds (inner core).
3. **Fiber Refinement**
   Depending on end use, fibers may undergo scutching, hackling, or degumming.
4. **Seed Processing**
   Seeds are cleaned, hulled, and pressed into oil or milled into protein flour.
5. **Pyrolysis**
   Residues (including shiv, dust, and off-grade biomass) are pyrolyzed into biochar, syngas, and bio-oil.
6. **Secondary Conversion**
   Fibers enter textiles, composites, or insulation; shiv enters construction or pulp; cellulose can be extracted for packaging and bioplastics.

This cascading use model ensures that nearly 100% of the harvested biomass is valorized.

4.4.2 Energy Co-Products from Pyrolysis

Traditional hemp processing discards residues, but in CODE HEMP's model, pyrolysis adds both ecological and economic value:

- **Biochar**
  Applied to soils or sold as a carbon credit.
- **Syngas (pyrolysis gas)**
  Can be used for cooking energy in village settings or small-scale power generation (running turbines or gas engines).
- **Bio-oil**
  Can serve as a heating fuel or, with refinement, as a chemical feedstock.

This means processing hubs can become energy self-sufficient, lowering OPEX, and even supply surplus energy to local communities, addressing SDG 7 (Affordable and Clean Energy).

4.4.3 Spain Pilot – Centralized R&D Facility

Spain provides the controlled environment to establish an R&D-grade processing chain:

- One decortication line for fiber/shiv separation.
- Small-scale pyrolyzer for biochar and gas testing.
- Hempcrete mixing and binder testing labs.
- Oil pressing and food-grade processing units for seeds.

Objective
Collect detailed data on yields, quality, energy balances, and carbon sequestration to publish life-cycle assessments (LCAs) and refine business models.

4.4.4 Ghana Demonstrator – Decentralized “Spoke & Hub” Model

In Ghana, the model must address rural realities like dispersed farmers, weak infrastructure, and limited capital. The solution is a multi-tiered system:

- **Village Spokes**
  Smallholder cooperatives (many women-led) manage sowing, harvesting, seed cleaning, and basic retting. Low-cost community-scale pyrolysis units convert residues into biochar and syngas for local cooking fuel.
- **Regional Hubs**
  Larger facilities for decortication, oil pressing, and advanced pyrolysis. These hubs aggregate biomass from villages, standardize quality, and produce export-ready products (fiber bales, hemp oil, biochar credits).
- **Anchor Off-takers**
  Construction companies, ag-input distributors, and food processors ensure that outputs have reliable buyers.

This structure combines local ownership with economies of scale, ensuring both community benefits and investor-grade consistency.

4.4.5 Logistics Design

Transport is a critical cost and carbon factor. Hemp stalks are bulky and low in value before processing; transporting them over long distances erodes margins. For this reason:

- **Maximum radius**
  Farms should be within 150 km of a hub, ideally 50–80 km.
- **Aggregation**
  Village cooperatives serve as collection points, reducing transaction costs.
- **Staggered planting**
  Phased sowing ensures staggered harvests, smoothing hub utilization rates.
- **Energy logistics**
  Surplus syngas can be bottled/distributed as clean cooking fuel; bio-oil can be stored and sold to regional buyers.

4.4.6 Strategic Advantages

By integrating processing and logistics into feasibility, CODE HEMP avoids the common pitfall of “grow now, process later.” Instead, it builds:

- **Circularity**
  Nearly 100% of biomass is utilized (food, fiber, composites, energy, carbon credits).
- **Community benefits**
  Villages gain direct access to clean cooking fuels and new enterprises.

- **Investor confidence**
  Hubs operate as predictable cash-generating assets, supported by anchor off-takers and carbon revenues.

4.5 Carbon Finance Potential

Financing the Great Green Wall requires innovative, high-integrity carbon finance models. Hemp delivers carbon services not just through fast biomass uptake, but also via durable pathways such as biochar and hempcrete. However, credibility is key: buyers demand CCP-approved standards, robust MRV (Monitoring, Reporting, Verification), and co-benefits for communities. CODE HEMP positions itself within this evolving architecture by leveraging both established registries (Verra, Gold Standard, Puro.earth) and emerging standards tailored for smallholder contexts (Carbon Standards International).

4.5.1 The Carbon Services of Industrial Hemp

Hemp provides a multi-layered carbon profile that combines fast uptake with durable storage — a rare feature among restoration crops. This makes it particularly valuable for the Great Green Wall, where credibility and permanence are essential to attract carbon finance.

1. **Rapid biomass growth (short-term sequestration):**
   - Hemp grows to maturity in 90–120 days, absorbing 3–15 tCO_2e/ha/year through fast accumulation of stalk, leaves, and roots.
   - Although much of this carbon is re-released if residues decompose, it provides crucial short-term sequestration and creates biomass feedstock for durable products such as biochar and hempcrete.
2. **Biochar (durable storage):**
   - Pyrolysis stabilizes 25–35% of the plant's carbon into biochar, which is resistant to microbial breakdown.
   - Studies[28] recognizes biochar as a durable removal technology, with lifetimes ranging from decades to centuries depending on soil conditions.
   - Hemp residues can yield 0.8–1.8 t biochar per hectare, equivalent to 2–5 tCO_2e locked away per season.
3. **Hempcrete (built environment storage):**
   - Hemp-lime composites continue to absorb CO_2 during curing and store it throughout the lifetime of buildings.
   - Life Cycle Assessments (IsoHemp, Liège University 2024) show hempcrete walls can deliver net-negative balances of up to –75 $kgCO_2e/m^3$ of material, depending on binder choice and system boundaries.
   - With Africa's projected housing deficit exceeding 130 million units by 2030 (IFC**)**, hempcrete has the potential to become a major carbon sink across the GGW region.
4. **Soil carbon (incremental gains):**

[28] E.g. European Commission - DG for Climate Action: Support to the development of methodologies for the certification of industrial carbon removals with permanent storage - Review of carbon removals through biochar; https://climate.ec.europa.eu/document/download/51aaaada-e29b-4bce-a34e-878d4d264846_en?filename=policy_carbon_expert_review_biochar_en.pdf

    - Hemp's deep root system (up to 1–2 m) helps to break compaction and deposit organic matter below the surface.
    - Evidence from regenerative rotations in southern Spain shows that soil organic carbon can improve under diversified cropping and organic amendments, though typically over multi-year cycles rather than single seasons.
    - Hemp rotations in Spain therefore represent an untested but promising hypothesis: by integrating hemp into semi-arid systems, measurable SOC improvements may be realized. The CODE HEMP pilot will explicitly measure SOC baselines and seasonal dynamics to validate this.

Industrial hemp delivers a stacked set of carbon benefits — fast uptake through biomass, medium-term fertility through soil carbon, and long-term removals through biochar and hempcrete. For the GGW, this diversity reduces integrity risks and creates multiple pathways for credible carbon finance.

4.5.2 Carbon Market Trends (2024–2025)

The carbon market landscape has undergone dramatic changes in the last two years, shaping the opportunity space for CODE HEMP:

- **Compliance markets expanding**
    - Carbon pricing revenues reached USD 104 billion in 2023, a 20% increase from 2022
    - 73 carbon pricing instruments are now in force, covering ~24% of global GHG emissions.
    - New African ETS pilots are emerging, including in South Africa, Nigeria, and Kenya, which could eventually create demand for African hemp credits.
- **Voluntary Carbon Market (VCM) reset**
    - After scandals over low-quality offsets in 2023, VCM volumes fell ~25%.
    - Buyers are now avoiding avoidance credits (e.g., REDD+ without permanence guarantees) and focusing on removals with durability.
    - Durable credits (biochar, DAC, BECCS) are increasingly seen as "gold tier."
- **High-integrity removals premium**
    - Biochar credits regularly sell at USD 100–150/tCO_2e.
    - Swiss Re, Microsoft, and Shopify have signed multi-year offtakes for biochar CRCs, with 10-year contracts locking in minimum volumes.
    - The voluntary carbon market grew by only 3% from 2022 to 2023. This contrasts with the much smaller market for carbon removal credits, which grew by 50%[29].
- **Integrity frameworks rising**
    - The **I**CVCM Core Carbon Principles (CCPs) launched in 2023, requiring permanence, additionality, MRV rigor, and no double counting.

[29] Carbon Direct, Ten insights for buyers from our 2024 voluntary carbon market report: https://www.carbon-direct.com/insights/ten-insights-for-buyers-from-our-2024-voluntary-carbon-market-report

    - Registries like Verra and ACR are reworking methodologies to achieve CCP approval, while Puro.earth and Carbon Standard International already aligns with removals markets.
    - Buyers increasingly demand CCP-approved credits only — projects outside this alignment may struggle to find premium buyers.

Industrial hemp-based carbon projects (biochar, hempcrete) fall into the exact category now most in demand: **durable removals with co-benefits.**

4.5.3 Methodologies & Standards

CODE HEMP plans to engage across a portfolio of standards:

- **Verra (VM0044 Biochar Utilization)**
  Currently the most widely recognized methodology for biochar projects; includes MRV protocols for feedstock tracking, pyrolysis efficiency, and carbon stability.
- **Puro.earth**
  A registry specializing in engineered removals. Puro's Biochar methodology is CCP-aligned and has already facilitated corporate offtakes in Europe and North America.
- **Gold Standard / Verra (Soil Carbon)**
  Offer SOC accounting methodologies but require longer monitoring (5–10 years). Useful as a secondary credit stream.
- **Emerging Hempcrete Methodologies**
  Currently under academic and NGO development. CODE HEMP can provide pilot data from Spain to accelerate standardization of hemp-lime building credits.
- **Carbon Standards International (CSI)**
  A breakthrough for artisanal biochar projects, enabling small-scale producers (e.g., village pyrolysis units in Ghana) to access carbon markets without prohibitive MRV costs. CSI methodologies are designed for decentralized, low-tech pyrolyzers, exactly the model that CODE HEMP will deploy in Ghana.

By combining mainstream registries (to attract institutional buyers) with CSI artisanal pathways (to empower local communities), CODE HEMP creates a hybrid carbon finance architecture that balances bankability and inclusivity.

4.5.4 Integration into CODE HEMP Pilots

Spain (Pilot):

- Conduct detailed Life Cycle Assessments (LCAs) of hempcrete, fiber, and biochar.
- Register credits under a standard to prove CCP compliance.
- Develop standardized MRV templates that can be transferred to African contexts.
- Engage with European buyers to secure advance purchase agreements (APAs) for credits, de-risking future cash flows.

Ghana (Demonstrator):

- Deploy artisanal pyrolyzers managed by women's cooperatives.

- Register credits under Carbon Standards International (CSI), which lowers MRV barriers and emphasizes community inclusion.
- Bundle carbon credits with SDG co-benefits such as clean cooking (syngas replaces firewood), women's employment, soil fertility.
- Position Ghana as the first African industrial hemp-based carbon project, creating demonstration value for other Sahelian states.

4.5.5 Risks & Mitigation

- **Permanence Risk**
  Hemp biomass is short-lived, but CODE HEMP mitigates this by prioritizing biochar (100+ years stability) and hempcrete (50+ years building lifetimes).
- **Additionality Risk**
  Credits will only be claimed for hemp grown on degraded or underutilized land not otherwise profitable. Land-use baselines will be independently verified.
- **MRV Costs**
  CSI methodologies significantly reduce MRV costs for artisanal projects, while Spain generates robust scientific baselines for scaling.
- **Market Volatility**
  Long-term offtake agreements with corporates will hedge against short-term VCM price swings.
- **Reputation Risk**
  Transparent data publication and third-party verification ensure integrity, avoiding the backlash seen in some forestry offsets.

4.5.6 Strategic Advantages

CODE HEMP's carbon finance model provides unique selling points for investors and buyers:

- **High Integrity**
  Credits aligned with ICVCM's Core Carbon Principles.
- **Durable Removals**
  Biochar and hempcrete provide long-term storage, the most valued category in the VCM.
- **Community Co-Benefits**
  Artisanal biochar provides clean cooking energy, women's jobs, and soil fertility — delivering strong SDG alignment (SDG 5, 7, 13, 15).
- **Diversified Pathways**
  Spain focuses on industrial-scale CCP credits, Ghana on CSI artisanal credits.
- **First-Mover Advantage**
  Industrial hemp has not yet been widely integrated into carbon markets; CODE HEMP can establish a new class of credits with high differentiation.

Carbon finance makes CODE HEMP not just an agricultural project but a climate investment platform. By combining mainstream CCP-approved registries with Carbon Standards International's artisanal methodologies, CODE HEMP ensures carbon revenues are credible, durable, and inclusive:

- For buyers, this delivers premium removals with powerful co-benefits.
- For communities, it provides a direct income stream from climate services.
- For the Great Green Wall, it provides a sustainable financing engine to move beyond donor dependency.

4.6 Employment & Women's Economic Empowerment

No economic strategy for Africa can ignore the role of women. Women make up the majority of the agricultural workforce, yet they are systematically excluded from land ownership, finance, and market access. For the GGW to succeed, it must not only create jobs but also **empower women as leaders, entrepreneurs, and innovators**. Hemp is particularly suited for gender-smart strategies: seed processing, food enterprises, textile crafts, and biochar micro-enterprises are all accessible entry points. By embedding gender quotas and women-led coops, CODE HEMP aligns with the AfDB, World Bank, and EU priorities on gender inclusion.

4.6.1 Employment Potential Along the Hemp Value Chain

To assess how hemp can transform livelihoods, we must look at where jobs are created along every link — from field work to processing, value addition, sales and clean energy. This section maps the full employment potential of hemp in rural zones and examines where women and youth can gain the most advantage. Industrial hemp offers **jobs at every stage** of its production and processing:

- **Cultivation**
  Sowing, weeding, harvesting — labor-intensive, providing opportunities for both men and women.
- **Primary processing**
  Retting, decortication, seed cleaning — suitable for small-scale cooperative models, where women can take leadership roles.
- **Secondary processing**
  Oil pressing, food milling, textile preparation, composite blending — provides semi-skilled employment in rural hubs.
- **Distribution & marketing**
  Sales of hemp food products, biochar, or clean cooking fuels create entrepreneurial opportunities for women-led micro-enterprises.

Evidence from other labor-intensive value chains in Africa (cotton, shea, cassava) shows that women often dominate processing and trade stages, even if men dominate cultivation. By designing industrial hemp value chains intentionally around this dynamic, CODE HEMP can ensure gender-balanced employment distribution.

4.6.2 Barriers for Women in Agricultural Value Chains

Even though women contribute significantly to agriculture, systemic hurdles—like land rights, credit access, and knowledge gaps—limit how much they benefit. Before designing gender-responsive strategies, we must understand those barriers in depth. Despite their central role, women face structural barriers:

- **Land access**
  In Sub-Saharan Africa, less than 15% of women hold land titles, even though they contribute up to 60–80% of food production[30].
- **Finance**
  Women-owned agribusinesses receive less than 10% of available credit[31].
- **Technology & training**
  Agricultural extension services disproportionately reach men, limiting women's access to improved inputs and practices.
- **Market access**
  Women are often confined to informal trade with low margins, while men dominate formal and export markets.

If left unaddressed, industrial hemp could replicate these inequalities. CODE HEMP instead positions women as primary beneficiaries of new opportunities.

4.6.3 Women's Roles in Specific Hemp Value Chains

Hemp value chains present multiple entry points where women can lead: in seed processing, food, textiles, biochar, and energy. This section articulates where women can most feasibly take on roles as producers, processors, and entrepreneurs, and how those roles differ across chains.

- **Seeds & Food Processing**
  Women have a long tradition in small-scale food processing. Hemp oil pressing, flour milling, and health products are natural extensions. With training and microfinance, women's cooperatives could dominate this segment.
- **Textiles & Crafts**
  In many African regions, women already lead weaving and craft industries. Hemp fiber can feed into artisan textiles (local markets) and industrial nonwovens (export).
- **Biochar & Clean Energy**
  Women spend disproportionate time collecting firewood for cooking. Artisanal pyrolyzers operated by women's groups can supply both biochar (for soil/carbon credits) and syngas (for cooking fuel) — reducing drudgery, improving health, and generating income.
- **Entrepreneurship**
  Cosmetics, nutraceuticals, and eco-packaging are emerging markets where women can lead SMEs if barriers to capital and training are removed.

4.6.4 Gender-Smart Frameworks for CODE HEMP

To move beyond lip service, CODE HEMP adopts gender-lens criteria (e.g. 2X Challenge, AfDB's gender strategy) that set measurable thresholds for women's participation in management, ownership, and services. This section explains which frameworks will guide project design and investor screening. CODE HEMP explicitly integrates gender-lens investing frameworks:

[30] FAO, The status of women in agrifood systems, 2023: https://doi.org/10.4060/cc5343en
[31] ILO, Empower rural women - end poverty and hunger: the potential of African cooperatives, 2007: https://www.ilo.org/sites/default/files/wcmsp5/groups/public/%40africa/documents/publication/wcms_174990.pdf

- **2X Challenge Criteria (global DFI standard)**
    - ≥40% women in the workforce.
    - ≥30% women in management and governance.
    - Women-owned SMEs integrated into value chains.
    - Products/services designed for women end-users.
- **AfDB Gender Strategy (2021–2025)**
  Emphasizes women's economic empowerment as core to Africa's growth. CODE HEMP directly aligns by targeting women-led cooperatives in hemp processing and carbon credit generation.
- **EU Global Gateway**
  Prioritizes gender-sensitive investments. CODE HEMP's integration of women as producers, processors, and carbon credit beneficiaries makes it a **r**eady-made Global Gateway candidate.

4.6.5 Employment Multipliers and Youth

One job in processing or logistics creates secondary opportunities in transport, supply, service, and markets. This section estimates multiplier effects and explores how youth can be included through (vocational) training, entrepreneurship, and cooperative models. Hemp value chains are labour-intensive in early stages. Based on EU pilot data and African analogues:

- **Cultivation & primary processing**
  1 full-time equivalent job per 2–3 hectares.
- **Secondary processing & distribution**
  1 job per 5–10 hectares.
- **Carbon credit & clean energy enterprises**
  Additional jobs in MRV (Monitoring, Reporting, and Verification, meaning measuring soil organic carbon, recording biochar yields, women trained as auditors for artisanal carbon projects), energy distribution, and cooperative management.

For every 1,000 hectares under industrial hemp cultivation, CODE HEMP could generate 350–500 direct jobs, plus indirect jobs in logistics, input supply, and marketing. Youth employment is a priority for the GGW, and industrial hemp's short crop cycle means faster job creation than tree planting, which only yields economic benefits after years.

4.6.6 Social Impacts of Empowering Women

When women gain control of income and resources, the effects ripple outward: better nutrition, educational attainment, resilience to shocks, and stronger communities. This section outlines those multiplier social benefits and how hemp contributes uniquely. Beyond economics, empowering women has multiplier effects:

- Higher household nutrition (women reinvest 80–90% of their income in family welfare vs 30–40% for men).
- Improved education outcomes for children, especially girls.
- Reduced time poverty as pyrolysis gas replaces firewood collection.
- Greater resilience to climate shocks when women have secure income streams.

4.6.7 Risks and Mitigation

Gender-inclusive designs also come with risks—elite capture, cultural resistance, tokenism, or overwork. This section identifies those risks and offers **guardrails** (quotas, safeguards, capacity building) to ensure that women truly benefit in equitable, sustainable ways. Potential risks are:

- **Risk of elite capture**
  Male-dominated elites may monopolize land, licenses, or processing hubs.
  Mitigation**:** establish gender quotas in cooperative governance.
- **Cultural resistance**
  In some regions, women may face resistance to owning or managing enterprises.
  Mitigation**:** partner with local NGOs experienced in gender advocacy.
- **Access to finance**
  Women may lack collateral for loans.
  Mitigation**:** bundle carbon revenues into microfinance products targeted at women entrepreneurs.

Employment is where the Great Green Wall succeeds or fails. Industrial hemp offers not just jobs, but inclusive jobs that empower women and youth. By integrating gender-smart frameworks, CODE HEMP ensures women are not passive laborers but active entrepreneurs, managers, and credit holders. This strengthens the social fabric, builds resilience, and ensures donor and investor support.

For every hectare of industrial hemp, there is not just ecological regeneration but also human empowerment — the true multiplier effect of CODE HEMP.

4.7 Business Models

A project only becomes investable when its business models are clearly defined. CODE HEMP does not rely on one single approach but proposes three archetypes:

- Cooperative models for farmer ownership,
- Research consortia for technical validation, and
- PPPs for scaling.

Each model addresses a different stage—Spain, Ghana, and the wider Sahel—and together they provide a pathway from experimentation to scale. This section sets out how each model works, how risks are shared, and how value is distributed between communities and investors.

4.7.1 Research–Industrial Consortium (Spain Pilot)

To attract serious investors and policymakers, CODE HEMP must generate scientifically validated data on yields, LCAs, and carbon balances. Spain provides the perfect testbed due to its regulatory clarity, research institutions, and semi-arid climate relevance.

- **Structure**
  - Universities, research institutes, and industry partners co-invest in a pilot processing facility.
  - Equipment OEMs (decorticators, pyrolyzers) integrate R&D into their product pipelines.
  - Outputs: peer-reviewed data, verified MRV templates, material specifications (fiber, cellulose, hempcrete)
- **Benefits**
  - Establishes credibility of hemp as a climate-smart crop.
  - Produces transferable methodologies for Africa.
  - Attracts European funding (Horizon, Green Deal).
- **Risks & Mitigation**
  - Limited scalability → mitigate by designing data protocols explicitly for transferability.
  - Focus on CBD overshadowing → emphasize industrial hemp applications in construction, food, and carbon.

4.7.2 Cooperative + Anchor Off-taker (Ghana Demonstrator)

Smallholder farmers, many of them women, form the backbone of agriculture in the GGW region. However, without aggregation and guaranteed markets, their output cannot achieve economies of scale. The cooperative + anchor off-taker model addresses this by linking community-based cooperatives directly to stable demand.

- **Structure**
  - Farmers grouped into cooperatives (min. 40% women in leadership).
  - Cooperative oversees sowing, harvesting, seed processing, and pyrolysis.
  - Regional hub handles decortication, advanced pyrolysis, and quality control.
  - Anchor off-takers (construction firms, food companies, agricultural-input distributors) sign floor-price purchase agreements.
- **Benefits**
  - Farmers guaranteed predictable income streams.
  - Risk reduction through offtake agreements.
  - Empowerment of women's cooperatives as micro-enterprises.
- **Risks & Mitigation**
  - Elite capture → embed democratic governance and quotas.
  - Volatile markets → rely on diversified value chains and long-term contracts.

4.7.3 PPP with Blended Finance (Sahel Scale-Up)

Scaling across multiple GGW countries requires capital far beyond grants. Public–Private Partnerships (PPPs) with blended finance allow risks to be shared and returns distributed fairly.

- **Structure**
  - Public side
    National governments, AU, and GGW donors provide land access, policy support, and concessional finance.

    - Private side
      Investors, impact funds, and corporates co-invest in processing hubs and carbon MRV systems.
    - Finance blend
        - Grants for technical assistance and training.
        - Concessional loans for processing infrastructure.
        - Equity for carbon credit and product ventures.
        - Carbon pre-purchase agreements to derisk cash flow.
- **Benefits**
    - Leverages donor funds to unlock private investment.
    - Creates replicable hubs across the Sahel.
    - Ensures communities retain ownership via co-op stakes.
- **Risks & Mitigation**
    - Political instability → mitigate with AU/GGW framework agreements.
    - Donor dependency → embed strong private-sector roles early.

4.7.4 Cross-Cutting Features of All Models

Regardless of archetype, CODE HEMP's business models are designed with:

- **Gender quotas**
  In governance and employment (aligned with 2X Challenge).
- **Carbon finance integration**
  Biochar and hempcrete credits as revenue enhancers.
- **Local capacity building**
  (Vocational) training, extension, and cooperative management.
- **Circularity**
  100% of biomass utilized (fiber, seed, cellulose, biochar, syngas).

CODE HEMP's three archetypes — cooperative + anchor offtaker, research consortium, and PPP with blended finance — provide a clear pathway from pilot to scale. Spain generates credibility and data; Ghana demonstrates social and economic viability; Sahel-wide PPPs secure replication and scale. By embedding gender quotas, carbon revenues, and cooperative empowerment into each model, CODE HEMP ensures that hemp is not only a crop, but a sectoral engine for green growth.

Business Model Archetypes – Pilot, Demonstrator, Scale

Stage	Archetype	Core Features	Revenue / Impact Pathways	Risks & Mitigation
Spain (Pilot)	Research–Industrial Consortium	Universities, R&D institutes, and industry partners co-invest- Centralized processing line (decorticator, pyrolyzer, oil press)- Generates robust LCA and MRV templates	Data for carbon methodologies (biochar, hempcrete)- EU Horizon/Green Deal funding- Early carbon credit pilots with Verra/Puro.earth	Limited scalability → Design for transferability- CBD stigma → Emphasize industrial hemp
Ghana (Demonstrator)	Cooperatives + Anchor Offtakers	Smallholder coops (≥40% women leadership)- Community pyrolysis units for biochar + syngas- Regional hubs aggregate and process- Anchor buyers secure offtake	Stable farmer incomes- Women-led micro-enterprises in seed & biochar- Carbon credits under CSI (artisanal biochar)- Local clean cooking fuel distribution	Elite capture → Democratic governance, quotas- Market volatility → Diversified value chains, floor-price contracts
Sahel (Scale-Up)	PPP with Blended Finance	Public–private partnerships under AU/GGW framework- Governments provide land access, concessional finance- Investors fund hubs, MRV systems, carbon aggregation	Multi-country replication- Carbon credit pre-purchase agreements- Export-grade hemp products (fiber, cellulose, food)- Bankable hubs as cash-generating assets	Political instability → **AU/GGW

4.8 Financing Stack

Investors want to know not only what the opportunity is but also how it will be financed. Restoration projects often fail because financing is fragmented, mismatched, or overly dependent on grants. CODE HEMP proposes a blended finance structure: grants for risk-taking innovation, concessional loans for demonstration, and commercial debt and equity for scaling. Financing CODE HEMP requires a carefully layered architecture. Each stage of the pathway — pilot, demonstrator, and scale — has different capital needs and risk profiles. By blending grants, concessional loans, equity, carbon pre-purchases, and PPPs, CODE HEMP ensures long-term viability without dependency on a single instrument.

4.8.1 Grants & Technical Assistance

Early-stage innovation carries costs that cannot be recouped immediately — such as R&D, farmer training, and methodology development. Grants are essential to de-risk these phases and attract follow-on investment.

- **Source**
  EU Horizon/Green Deal, UNCCD GGW Facility, bilateral donors.
- **Target Share**
  15–20% of stack.
- **Use Cases**
  - Spain pilot: scientific validation, LCAs, MRV design.
  - Ghana demonstrator: training for women's cooperatives, extension services.
  - Methodology development for hempcrete and artisanal biochar credits.

4.8.2 Concessional Loans

Infrastructure (processing hubs, pyrolyzers, decorticators) is capital-intensive and unattractive to commercial lenders due to long payback horizons. Concessional loans from DFIs lower borrowing costs and extend tenors, making investment bankable.

- **Sources**
  AfDB, World Bank, regional DFIs (FMO, DEG, Proparco).
- **Target Share**
  30–40%.
- **Use Cases**
  - Ghana hubs: decortication, oil pressing, pyrolysis facilities.
  - Sahel hubs: cross-border logistics, storage, export corridors.

4.8.3 Equity & Impact Investment

Once proof-of-concept is achieved, equity is needed to scale commercially viable operations. Equity investors bring not just capital but also strategic partnerships (markets, technology, governance).

- **Sources**
  Impact funds, family offices, corporate investors (construction, FMCG, packaging).
- **Target Share**
  20–25%.
- **Use Cases**
  - Fiber/textile ventures for EU export.
  - Biocomposites and packaging industries.
  - Carbon credit project platforms.
  - Risk: Donor dependency.
    Mitigation: Private-sector role embedded early.

4.8.4 Carbon Pre-Purchase Agreements

Carbon revenues are a defining feature of CODE HEMP, but credits only materialize after harvest and verification. Pre-purchase agreements create **early liquidity** and reduce risk, effectively front-loading carbon finance.

- **Sources**
  Corporates with net-zero pledges (Microsoft, Google, Swiss Re, Shopify).

- **Target Share**
  10–15%.
- **Use Cases**
  - Financing artisanal biochar units in Ghana.
  - Covering MRV and registry fees.
  - Providing direct cash flow to women-led cooperatives.

4.8.5 Public–Private Partnerships (PPPs)

Scaling across Sahelian states requires coordination of land, logistics, and political risk-sharing. PPPs leverage donor and government commitments to unlock private sector investment at scale.

- **Sources**
  AU, national governments, GGW donors, private infrastructure funds.
- **Target Share**
  15–20%.
- **Use Cases**
  - Replication of hubs across multiple GGW countries.
  - Establishment of carbon MRV registries in Africa.
  - Infrastructure corridors (ports, energy grids, transport).

4.8.6 Financing Flow Design

The sequencing of finance is as important as the instruments themselves. CODE HEMP applies a stage-gated approach:

- Spain pilot → funded largely by **grants**.
- Ghana demonstrator → financed by **grants + concessional loans + carbon pre-purchases**.
- Sahel scale-up → driven by **equity + PPPs**, once proof of viability is achieved.

The financing stack is not a patchwork but a strategic architecture. Grants and concessional loans unlock early-stage feasibility, equity accelerates commercial expansion, and carbon pre-purchases bridge liquidity gaps. PPPs then anchor replication at scale. This blended approach ensures CODE HEMP is investable at every stage, while balancing public good objectives with private sector efficiency.

4.9 Risk–Return Profile

Every frontier investment carries risk. Industrial hemp carries its own risks: policy changes, market volatility, climatic stress, and social acceptance. But restoration also carries risks when trees fail, donors withdraw, or communities lose trust.

What distinguishes CODE HEMP is not the absence of risks, but the strength of its design in transforming risks into manageable parameters. CODE HEMP addresses these risks through diversification, high-quality carbon standards, policy engagement, and community ownership.

By openly acknowledging risks and offering mitigation strategies, the project positions itself as realistic rather than idealistic. By blending diversified value chains, carbon finance, gender

empowerment, and donor leverage, CODE HEMP offers a risk–return profile attractive to both donors and private investors.

4.9.1 Financial Risks

Agriculture in emerging markets often faces unstable cash flows due to commodity price swings, high input costs, and weak access to working capital. Carbon markets, while lucrative, are still volatile and fragmented. Addressing financial risks early is key to investor confidence.

- **Nature of Risk**
  Volatility in hemp product prices; liquidity constraints; uncertain carbon price trajectories.
- **Mitigation**
  - Diversified revenue streams (fiber, food, biochar, cellulose, carbon credits).
  - Long-term offtake agreements with anchor buyers.
  - Blended finance instruments to absorb downside risk.

4.9.2 Operational Risks

Infrastructure-heavy projects in rural Africa often fail due to weak logistics, unreliable power, and lack of skilled workforce. A decentralized model minimizes these risks by making systems resilient and modular.

- **Nature of Risk**
  Breakdowns in processing hubs; high logistics costs; weak supply chains.
- **Mitigation**
  - Spoke-and-hub structure: village-level preprocessing + regional hubs.
  - Energy self-sufficiency via pyrolysis gas and bio-oil.
  - Skills transfer from Spain pilot to African demonstrators.

4.9.3 Political & Regulatory Risks

Industrial hemp is still politically sensitive in many jurisdictions. Without clear regulations, licensing delays or bans could undermine viability. Ensuring alignment with multilateral frameworks provides predictability.

- **Nature of Risk**
  Regulatory uncertainty, stigma from association with cannabis, political instability in Sahel countries.
- **Mitigation**
  - Strict focus on industrial hemp (THC <0.3%).
  - Embedding within African Union GGW frameworks.
  - Using Spain pilot to establish precedents and credibility with regulators.

4.9.4 Market Risks

Industrial hemp markets in Africa are nascent. Export opportunities exist, but global markets demand certification and quality control. Without reliable buyers, revenues may underperform.

- **Nature of Risk**
  Limited domestic demand; quality standards for EU/US markets; carbon market volatility.

- **Mitigation**
    - Dual-market targeting (local food/energy + export-grade fiber and carbon).
    - Partnerships with EU processors for compliance and certification.
    - Multi-year carbon pre-purchase agreements with corporates.

4.9.5 Social & Environmental Risks

Projects that exclude women, displace farmers, or degrade soils lose their social license. For the GGW, inclusivity is a precondition for success.

- **Nature of Risk**
  Elite capture of coops, exclusion of women, land conflicts, unsustainable farming practices.
- **Mitigation**
    - Gender quotas in governance and workforce (2X Challenge alignment).
    - Land tenure due diligence before expansion.
    - Agroecological training and regenerative methods.

4.9.6 Return Potential

Investors require not only financial returns but also measurable impact. CODE HEMP offers both, by stacking revenues and embedding co-benefits that attract blended finance and impact capital.

- **Financial Returns:**
    - IRRs of 12–18% under blended finance structures.
    - Carbon credits priced at USD 100–150/tCO_2e provide high-margin upside.
- **Impact Returns:**
    - Employment: 350–500 jobs per 1,000 ha.
    - Women's empowerment: ≥40% women in workforce, ≥30% in leadership.
    - Climate: 2–5 tCO_2e/ha durable removals + clean energy substitution.
- **Strategic Returns:**
    - First-mover advantage in African hemp-based carbon removals.
    - Alignment with EU Green Deal, AfDB strategies, and GGW priorities.

4.9.7 Investor Value Proposition

Impact investors, DFIs, and corporates need to see both protection from downside risk and access to upside potential. CODE HEMP's design offers exactly this combination.

- **Value to Investors:**
    - Diversified, stacked revenue profile.
    - High-integrity carbon credits aligned with ICVCM and CSI.
    - Blended finance risk cushioning.
    - Clear exit strategies via SME spin-offs or PPP franchises.

CODE HEMP transforms high-risk frontier agriculture into a bankable climate-smart sector. By diversifying revenues, embedding carbon finance, and leveraging blended finance, it balances risks and rewards in a way that few GGW projects achieve. For investors, this means competitive IRRs with premium impact; for communities, it means jobs, resilience, and empowerment.

4.10 Scaling Pathway

Scaling is the difference between an interesting project and a transformative one. For the Great Green Wall, isolated pilots are not enough — the challenge requires solutions that can expand across regions and countries while maintaining quality and impact. CODE HEMP is designed as a **stage-gated pathway**: scientific validation in Spain, social and economic demonstration in Ghana, and continental replication across the Sahel.

This sequencing is intentional. Each stage reduces uncertainty, builds credibility, and strengthens the business case:

- **Spain Pilot**
  proves technical feasibility and delivers data.
- **Ghana Demonstrator**
  validates social acceptance, cooperative models, and carbon revenues.
- **Sahel Scale-Up**
  deploys at continental scale under Public–Private Partnerships.

By embedding carbon finance, gender-smart inclusion, and regenerative agriculture principles at each stage, the scaling pathway ensures that expansion is not only larger but also replicable, inclusive, and bankable.

4.10.1 Spain Pilot (2026–2027)

Spain offers semi-arid conditions similar to parts of the Sahel but with advanced research infrastructure and access to EU funding. A pilot here generates credible, peer-reviewed data on yields, LCAs, and carbon sequestration, which are essential for investor confidence and for building international standards.

- **Structure**
  - Establish a research–industrial consortium (universities, SMEs, equipment OEMs).
  - One pilot hub with decortication, oil pressing, pyrolysis, and hempcrete labs.
  - Funded primarily by grants and EU research programs (Horizon, Green Deal).
- **Benefits**
  - Peer-reviewed LCAs and MRV templates for carbon finance.
  - Yield and carbon data transferable to African contexts.
  - Early partnerships with EU buyers in construction, food, and composites.
- **Risks & Mitigation**
  - Risk: Seen as “too European”
    Mitigation: include African researchers in pilot consortium.
  - Risk: Limited scalability
    Mitigation: design all data protocols for replication.

4.10.2 Ghana Demonstrator (2027–2029)

Demonstrating industrial hemp’s viability in Africa requires field trials with real communities. Ghana provides political stability, established agribusiness ecosystems, and strong traditions of women’s cooperatives. A demonstrator here **proves the social, economic, and environmental benefits** of industrial hemp at scale.

- **Structure**
  - Cooperatives organized with ≥40% women members.
  - Village-level preprocessing and pyrolysis units linked to regional hubs.
  - Anchor off-takers (construction, food, ag-input distributors) secure demand.
  - Financed through grants, concessional loans, and carbon pre-purchases.
- **Benefits**
  - Demonstrates inclusive cooperative model.
  - Generates artisanal biochar credits under CSI standards.
  - Creates 350–500 jobs per 1,000 ha, with strong women's participation.
- **Risks & Mitigation**
  - Risk: Weak infrastructure
    Mitigation: decentralized spoke–hub system.
  - Risk: Social resistance
    Mitigation: partner with NGOs skilled in gender inclusion.

4.10.3 Sahel Scale-Up (2029–2035)

Once scientific credibility and social viability are established, scaling across Sahel countries becomes feasible. This requires **blended PPP frameworks** to mobilize large-scale capital and manage political risks.

- **Structure**
  - National hubs in 3–5 GGW countries (e.g. Senegal, Mali, Burkina Faso, Niger, Chad).
  - PPPs blending donor grants, concessional loans, private equity, and carbon revenues.
  - Regional carbon MRV registries set up for transparency and credibility.
- **Benefits**
  - Replication across GGW countries with AU/UNCCD support.
  - Tens of thousands of hectares restored.
  - 10,000+ direct jobs created, with strong focus on youth and women.
  - Millions of tons of CO_2 durably removed through biochar and hempcrete.
- **Risks & Mitigation**
  - Risk: Political instability
    Mitigation: anchor under AU/UNCCD frameworks.
  - Risk: Donor fatigue
    Mitigation: secure private-sector co-investment early.
  - Risk: Market saturation
    Mitigation: diversify into high-value sectors (biocomposites, packaging).

4.10.4 Cross-Cutting Scaling Principles

Scaling is not simply replication — it must preserve quality, inclusivity, and financial viability. These **principles** ensure each stage reinforces the others.

- **Modularity**
  Each hub operates independently, reducing systemic risk.

- **Inclusivity**
  Gender quotas and youth employment embedded at every stage.
- **Carbon Integration**
  Biochar and hempcrete credits monetized from pilot to scale.
- **Policy Alignment**
  All phases linked to GGW, AU Agenda 2063, and SDG 13.

4.10.5 Scaling Benefits

- **Ecological:** Soil restoration, erosion control, reduced desertification.
- **Economic:** Diversified livelihoods, higher farmer incomes, FDI attraction.
- **Climate:** Millions of tons of CO_2 durably sequestered.
- **Social:** Women-led cooperatives and youth enterprises embedded in new value chains.

The scaling pathway ensures CODE HEMP evolves from a promising pilot to a **continental solution**. Spain proves the science, Ghana proves the socio-economic model, and Sahel replication proves large-scale impact. Each stage reduces risk, strengthens credibility, and builds investor confidence. Together, they transform hemp into a bankable platform for restoration, livelihoods, and climate finance in Africa.

4.11 Monitoring & Impact

Impact claims only matter if they are **c**redible and verifiable. For CODE HEMP, monitoring and impact assessment are not compliance checkboxes, but core elements of the business model. Transparent and standardized reporting builds trust with investors, creates accountability to communities, and enables carbon revenues under ICVCM and other registries.

The monitoring system therefore spans **four pillars**: climate, land, livelihoods, and gender empowerment. Each pillar is aligned with internationally recognized frameworks — the **I**CVCM Core Carbon Principles (CCPs) for climate integrity, the UNCCD Land Degradation Neutrality (LDN) indicators for land restoration, the IFAD/World Bank livelihood indicators for rural income and jobs, and the 2X Challenge criteria for gender inclusion. Together, these create an **impact dashboard** that provides both financial-grade assurance for investors and participatory feedback for communities.

4.11.1 Climate Impact

Carbon finance is a cornerstone of CODE HEMP's business model. To monetize removals and ensure credibility, climate impacts must be measured with high-integrity MRV systems.

- **Metrics**
  - CO_2 removals via biochar (tCO_2e/ha).
  - Hempcrete carbon storage ($kgCO_2e/m^2$ of wall).
  - Soil organic carbon changes (SOC % over baseline).
- **Methods**
  - Standardized LCAs (Spain pilot).
  - ICVCM-aligned methodologies (Verra, Puro.earth, CSI).
  - Remote sensing + field sampling for biomass and SOC.

- **Outputs**
    - Verified carbon credits under CCP-approved standards.

4.11.2 Land Restoration Impact

The Great Green Wall is fundamentally a land restoration program. CODE HEMP must prove that it contributes to reversing desertification and restoring soil fertility.

- **Metrics**
    - Hectares of degraded land restored.
    - Soil fertility indices (organic matter %, nutrient content, water retention).
    - Reduction in soil erosion rates.
- **Methods**
    - UNCCD Land Degradation Neutrality (LDN) indicators.
    - Field soil tests combined with satellite monitoring.
- **Outputs**
    - Annual land restoration maps integrated into GGW reporting systems.

4.11.3 Livelihood Impact

Hemp's promise is not just ecological, but socio-economic. Livelihood improvements are the most visible success factor for communities and donors alike.

- **Metrics**
    - Jobs created per 1,000 hectares (target: 350–500).
    - Household income increases (USD per season).
    - Access to clean cooking energy (households using syngas instead of firewood).
- **Methods**
    - Household surveys capturing changes in income, energy use, and resilience.
    - Cooperative-level financial reporting on revenues and distributions.
    - Impact assessments aligned with **IFAD and World Bank livelihood indicators**, which emphasize income, food security, and access to basic services as core measures of rural transformation.
- **Outputs**
    - Annual impact reports showing measurable income growth, employment creation, and household-level improvements in welfare.

4.11.4 Gender & Inclusion Impact

Empowering women and youth is central to CODE HEMP's legitimacy. Monitoring ensures that inclusion goals are met in practice, not just in rhetoric.

- **Metrics**
    - % of women in workforce (target: ≥40%).
    - % of women in leadership (target: ≥30%).
    - Youth participation rates in training and employment.
- **Methods**
    - Gender-disaggregated data collection at cooperative and hub level.
    - Independent NGO audits of inclusion practices.

- **Outputs**
    - Alignment with **2X Challenge criteria** for gender-smart investing.

4.11.5 Financial Transparency & Governance

Investors demand financial-grade impact data. Communities demand accountability in how revenues are shared. Transparent governance ensures both.

- **Metrics**
    - Carbon credit revenues distributed to cooperatives.
    - Share of cooperative income reinvested locally.
    - % of financing reaching women-led enterprises.
- **Methods**
    - Blockchain-based traceability for carbon credit revenues (planned).
    - Cooperative-level participatory audits.
- **Outputs**
    - Annual “Impact Dashboard” integrating climate, land, livelihoods, and gender results.

4.11.6 MRV Architecture

Strong MRV (Monitoring, Reporting, Verification) systems are essential to prevent greenwashing and ensure market access. CODE HEMP builds MRV into every stage.

- **Design**
    - Spain pilot develops standardized MRV templates.
    - Ghana demonstrator tests participatory MRV (community-led data collection).
    - Sahel scale-up integrates MRV into AU/UNCCD monitoring systems.
- **Benefits**
    - Reduced verification costs at scale.
    - Increased community ownership of data.
    - Bankability through CCP-aligned crediting.

Monitoring & Impact is the backbone of CODE HEMP’s credibility. By embedding climate, land, livelihoods, and gender into a single dashboard, the project delivers transparent, verifiable outcomes that meet the standards of both international investors and local communities. With ICVCM and 2X Challenge frameworks at its core, CODE HEMP positions itself as one of the first bankable restoration projects in the Great Green Wall that can deliver financial-grade impact reporting at scale.

Impact Dashboard – CODE HEMP

Pillar	Key Metrics	Reference Framework	Outputs
Climate	- CO_2 removals via biochar (tCO_2e/ha) - Hempcrete storage ($kgCO_2e/m^2$) - Soil organic carbon changes (%)	ICVCM Core Carbon Principles (CCPs) Verra VM0044 Puro.earth Carbon Standards International (CSI)	- Verified carbon credits issued annually - Published LCAs and MRV reports
Land	- Hectares of degraded land restored - Soil fertility indices (OM %, nutrients, water retention) - Reduction in erosion rates	UNCCD Land Degradation Neutrality (LDN) indicators	- Annual land restoration maps - Soil monitoring datasets shared with GGW
Livelihoods	- Jobs created per 1,000 ha (target: 350–500) - Household income increase (USD/season) - Access to clean energy (households using syngas)	IFAD & World Bank livelihood indicators	- Annual household income survey results - Cooperative employment reports - Clean cooking adoption statistics
Gender & Inclusion	- ≥40% women in workforce - ≥30% women in leadership - Youth participation rates in training & jobs	2X Challenge gender-smart criteria	- Gender-disaggregated data reports - Independent NGO gender audits - 2X compliance certificates

4.12 Conclusion

Chapter 4 has laid out the economic opportunities, business models, financing stack, risk–return profile, scaling pathway, and monitoring system for CODE HEMP. Together, these components demonstrate that hemp is not a speculative idea but a bankable and transformative solution for the Great Green Wall. The conclusion highlights why CODE HEMP represents a unique convergence of science, business, and social impact, making it one of the most promising platforms for climate-smart investment in Africa.

CODE HEMP demonstrates that **industrial hemp is a feasible, scalable, and inclusive solution** for the Great Green Wall. It transforms degraded land into productive value chains, provides diversified incomes for farmers, empowers women and youth, and generates bankable carbon credits. The project balances risk with opportunity, science with community, and donor support with private capital.

Proof of Concept (Rationale: Science First)

Any scalable intervention begins with credible data. The Spain pilot provides peer-reviewed LCAs, MRV templates, and yield studies, grounding CODE HEMP in science, not hype. This ensures that investors and policymakers can make decisions based on verified evidence rather than untested assumptions.

Inclusive Demonstration (Rationale: People First)
The Ghana demonstrator validates industrial hemp's social and economic viability. By embedding women's cooperatives, youth employment, and artisanal biochar into the model, CODE HEMP ensures that restoration delivers livelihoods and empowerment — not just ecological benefits. This stage proves that hemp can restore land while lifting communities out of poverty.

Scalable Model (Rationale: Replication)
The Sahel scale-up translates pilot and demonstration success into a continental strategy. With PPPs and blended finance, the model becomes replicable across multiple GGW countries. The design principles — modular hubs, carbon finance integration, gender quotas — ensure scalability without loss of integrity. Hemp thereby shifts from a niche crop to a sectoral growth engine for the Sahel.

Investor Proposition (Rationale: Bankability)
For donors and impact investors, CODE HEMP offers a unique risk–return profile:

- **Financial returns**
  (IRR 12–18% with carbon credit upside).
- **Impact returns**
  (jobs, gender empowerment, land restored).
- **Strategic returns**
  (alignment with EU Green Deal, AfDB climate strategy, UNCCD GGW).

This diversification ensures that CODE HEMP is not only sustainable but also attractive to mainstream capital.

Transformational Impact (Rationale: Systems Change)
The true conclusion is not in individual metrics but in systemic change. Industrial hemp offers:

- **Ecological transformation**
  Restoring degraded soils and capturing carbon.
- **Economic transformation**
  Creating livelihoods and industries in rural Africa.
- **Social transformation**
  Empowering women, strengthening communities.
- **Policy transformation**
  Embedding a new sector into GGW frameworks.

By combining these dimensions, CODE HEMP turns the Great Green Wall into more than a line of trees — it becomes a living economic corridor powered by regenerative agriculture.

For donors, it offers measurable impact on **SDGs 5, 7, 8, 13, and 15**. For investors, it offers a rare frontier opportunity with strong downside protection and high-impact upside. For communities, it offers dignity, income, and empowerment.

5. Policy Brief & Recommendations

The Great Green Wall (GGW) is one of the most ambitious restoration initiatives of our time, but its fragmented progress highlights **a need for new approaches** that combine ecology, livelihoods, and finance. CODE HEMP demonstrates how industrial hemp can support the GGW by creating regenerative value chains that generate jobs, empower women, and deliver durable carbon removals.

This Policy Brief distills the findings of the feasibility study into actionable recommendations for policymakers, donors, and investors. It is intended for the

- African Union and GGW Agency,
- National governments in Sahelian countries,
- EU and bilateral donors,
- Development finance institutions (DFIs), and
- Impact investors.

5.1 Key Messages

1. **The GGW needs integrated restoration strategies** that combine ecological regeneration with viable economic models. Hemp offers such a pathway.
2. **Women and youth must be at the center** of restoration — not as beneficiaries, but as active entrepreneurs and cooperative leaders.
3. **Carbon finance is a game-changer** as durable removals (biochar, hempcrete) are in high demand and can fund restoration if aligned with ICVCM standards.
4. Scaling requires a **blended finance stack** composed of grants for R&D and training, concessional loans for infrastructure, equity for scaling, and carbon pre-purchases for liquidity.
5. Policy frameworks must enable **industrial hemp cultivation, processing, and carbon credit registration** without regulatory ambiguity.

5.2 Policy Recommendations by Level

5.2.1 African Union / GGW Agency

Continental leadership is required to create harmonized frameworks and mobilize donor support.

- **Integrate industrial hemp** as a recognized restoration crop in GGW strategies.
- Establish a **continental registry of hemp-based carbon credits** under AU/UNCCD oversight to ensure credibility.
- Promote **regional knowledge exchange platforms** for hemp agronomy, biochar, and cooperative models.
- Align CODE HEMP with **Agenda 2063** and **African Climate Strategy 2022–2032**.

5.2.2 National Governments (Sahel Countries)

National policies must create an enabling environment for cultivation and value chains.

- Revise legal frameworks to clearly **differentiate industrial hemp (THC <0.3%) from cannabis**, reducing stigma and bureaucratic barriers.
- Support **women's and youth cooperatives** with land access, training, and start-up finance.
- Integrate industrial hemp into **national climate and land restoration plans** as part of NDCs (Nationally Determined Contributions under the Paris Agreement).
- Provide **tax incentives** for companies investing in industrial hemp processing hubs.

5.2.3 EU & International Donors

Donors provide catalytic funding and set international standards for credibility.

- Fund the **Spain pilot** as an EU–AU demonstration of circular bioeconomy for restoration.
- Support African governments with **technical assistance** for industrial hemp regulation and MRV systems.
- Recognize industrial hemp-based carbon credits under the **EU Carbon Removal Certification Framework (CRCF)**.
- Include industrial hemp-based projects in EU's **Global Gateway investments** and in the African Green Deal agenda.

5.2.4 Development Finance Institutions (DFIs) & Investors

DFIs and impact investors bridge the gap between grants and private capital.

- Provide **concessional loans** for processing hubs and logistics infrastructure.
- Invest equity in **industrial hemp-based SMEs** producing food, construction materials, and composites.
- Secure **long-term carbon pre-purchase agreements** (Microsoft, Google, Shopify, Swiss Re already engage in biochar removals at USD 100–150/tCO_2e).
- Apply **gender-smart investing standards** (2X Challenge) to ensure women-led enterprises benefit from financing.

5.3 Evidence Base for Recommendations

- **Fragmentation of GGW**
  UNEP (2020) *The Great Green Wall Implementation Status and Way Ahead to 2030* found that only ~4 million hectares of the 100 million target had been restored by 2020 — less than 15% of the 2030 goal. Main barriers: funding, coordination, and lack of economically viable crops.
- **Role of women**
  FAO (2023) *The Status of Women in Agrifood Systems* shows women make up 39.6% of global agricultural labor but own <15% of land and receive <10% of credit. Empowerment is therefore essential for equity and efficiency.
- **Carbon removals market**
  World Bank (2024) *State and Trends of Carbon Pricing* notes carbon pricing revenues exceeded USD 104 billion in 2023; durable removals (biochar, BECCS, DAC) are the fastest-growing segment, selling at USD 100–150/tCO_2e.

- **Industrial Hemp regulation potential**
  Countries like Canada, France, and China demonstrate how clear industrial hemp policies can stimulate export markets worth billions.

5.4 Policy Case

The Great Green Wall will only succeed if it becomes more than a planting program. It must be a development platform that regenerates land while creating jobs, empowering women, and attracting investment. Industrial hemp offers a unique opportunity to achieve this integration.

By adopting the recommendations outlined here — harmonized regulation, gender empowerment, carbon finance integration, and blended financing — policymakers and donors can unlock CODE HEMP as a flagship initiative that makes the GGW both ecologically resilient and economically sustainable.

6. Final Outlook & Next Steps

This feasibility study has demonstrated that industrial hemp can become a transformative catalyst for the Great Green Wall. It combines ecological regeneration with viable business models, gender empowerment, and carbon finance. Chapter 6 outlines the next steps for CODE HEMP — from pilot validation to investor engagement — and provides a final outlook on its role in reshaping restoration and rural economies in Africa.

6.1 Strategic Outlook

To move from feasibility to reality, CODE HEMP must align itself with global megatrends in climate finance, green industrialization, and inclusive development.

- **Ecological Outlook**
  Industrial hemp can restore millions of hectares of degraded land by 2035, complementing tree planting with short-cycle, high-yield regenerative cropping.
- **Economic Outlook**
  With diversified value chains, industrial hemp can generate resilient incomes, new SMEs, and FDI opportunities.
- **Social Outlook**
  Women and youth become central actors in restoration, making the GGW a people-centered initiative.
- **Climate Outlook**
  Industrial hemp-based carbon removals can position Africa as a leader in durable carbon credits, supplying a premium global market.

6.2 Next Steps (2025–2029)

Investors and donors require a **clear implementation roadmap**. CODE HEMP proposes a four-phase roll-out:

1. **2025–2026 | Project Setup & Partnerships**
   - Finalize consortium agreements with EU, AU, research institutions, and private partners.
   - Secure EU Horizon/Green Deal funding for Spain pilot.
   - Conduct baseline studies (land, livelihoods, carbon).
2. **2026–2027 | Spain Pilot**
   - Launch pilot hub for decortication, pyrolysis, and hempcrete R&D.
   - Publish LCAs and MRV templates.
   - Begin engagement with Verra, Puro.earth, and CSI for methodology integration.
3. **2027–2029 | Ghana Demonstrator**
   - Establish women- and youth-led cooperatives.
     Deploy decentralized pyrolysis units and regional hubs.
   - Issue first hemp-based carbon credits under CSI.
   - Document social and economic impact for donor/investor reporting.
4. **2029–2035 | Sahel Scale-Up**
   - Expand hubs to at least 3–5 GGW countries.

- Anchor PPPs under AU and UNCCD GGW frameworks.
- Integrate hemp into national NDCs and GGW country strategies.
- Achieve multi-million tCO_2e removals and tens of thousands of jobs.

6.3 Investor & Donor Engagement

A blended pipeline requires multiple entry points for different stakeholders.

- **Donors & Philanthropy**
  Early-stage grants (R&D, training, cooperative building).
- **Development Finance Institutions (DFIs)**
  Concessional loans for processing hubs.
- **Impact Investors**
  Equity in scalable SMEs and carbon projects.
- **Corporate Buyers**
  Carbon pre-purchase agreements and off-take contracts for hempcrete, food, and biocomposites.

CODE HEMP will establish an **Investor Forum in 2026** to align partners and secure advance commitments.

6.4 Risks & Enablers for the Outlook

A forward-looking chapter must acknowledge uncertainties while also showing how they can be overcome.

- **Risks**
  Political instability, donor fatigue, infrastructure gaps, regulatory delays.
- **Enablers**
  AU/UNCCD frameworks, EU–AU partnerships, carbon finance, gender quotas, circular economy demand.
- **Leverage Points**
  Spain pilot data, Ghana demonstrator success, and early carbon credit issuance.

6.5 Final Conclusion

CODE HEMP has the potential to redefine the Great Green Wall:

- From fragmented projects → to an integrated platform.
- From donor dependency → to blended finance and carbon revenues.
- From tree planting → to regenerative economies powered by hemp.

By following the staged pathway outlined in this study, CODE HEMP can create a continental movement that restores land, empowers women, generates jobs, and delivers bankable carbon removals. CODE HEMP transforms restoration **from a cost into an opportunity** — for Africa, for investors, and for the planet.

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Further Reading

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- **UNCCD (2024). *Independent Review of the Great Green Wall Accelerator*.** Evaluates the implementation of the GGW Accelerator, including funding flows, coordination gaps, and scaling challenges.

- **World Bank (2024). *State and Trends of Carbon Pricing 2024*.** Annual flagship report on carbon markets and pricing developments, with special insights on removals.

- **IPCC (2022). *Climate Change 2022: Mitigation of Climate Change* (WG III Contribution to the Sixth Assessment Report).** Includes a key section on carbon removals and the role of land-based solutions.

- **FAO (2023). *The Status of Women in Agrifood Systems*.** Landmark study on women's roles in agriculture, highlighting persistent barriers in land access, finance, and value chains.

- **African Union (2022). *Agenda 2063: The Africa We Want – Ten-Year Implementation Report*.** Frames the GGW in the broader context of Africa's development strategy.