



DECON HEMP

Decontamination of soil through Industrial Hemp

Feasibility study for the decontamination of
heavy metal-polluted mining areas in Ghana



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German Federal Association for Sustainability
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Liebenwalder Str. 33
13347 Berlin

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Authors:

Martin Wittau, Germany
Jesus Lopez Nunez, USA
Ada Guclu, USA
Annika Brucia, USA
Avalon Kelly, USA
Cassandra Carraher, USA
Jay Nguyen, USA
Mavis Ama Yeboah, Ghana

Review:

Dr. rer. nat. Cosmas Kombat Lambini, Ghana
Research Consultant
International Institute for Environment and Development, London (United Kingdom)

Francesco Tonolo
Researcher
Above-Belowground Interactions Research Group, Leiden University (The Netherlands)

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Table of Contents

Imprint	2
Table of Contents	3
Foreword	7
Acknowledgement	9
About the Editors	10
The Linnaeus Competence Center Hemp	10
The German Federal Association for Sustainability	10
Shared Mission	10
Executive Summary	11
Scientific and Technical Rationale	11
Project Objectives and Approach	11
Economic and Social Viability	12
Policy, Legal, and Institutional Context	12
Expected Outcomes	13
Strategic Significance	13
Main Conclusions	14
1. Background	16
1.1 Overview of Environmental Contamination in Ghana	16
1.2 Problem Statement	18
1.3 Study Goal	18
1.4 Scope of the Study / SDGs Alignment	19
2. Scientific and Technical Basis	21
2.1 Mechanisms of Phytoremediation	21
2.2 Phytomining and Biomass Valorization	22
2.3 Limitations of Industrial Hemp for Phytoremediation	23
2.4 Comparative Analysis	23
2.5 Sustainability and Suitability for Ghana	27
2.6 Case Studies of Industrial Hemp and Phytoremediation	27
2.7 Complementary Use of Biochar for Water and Non-Plantable Areas	28
3. Social, Health and Economic Impact Assessment	29
3.1 Social Impact	29
3.2 Health Impact	30
3.3 Impact on Fertility and Reproductive Health	30
3.4 Economic Impact	31
3.5 Environmental Co-Benefits	32
3.6 Long-Term Social Transformation	32

4. Vulnerability and Needs Assessment	33
4.1 Overview of Affected Populations	33
4.2 Farmers: Loss of Livelihoods and Ecological Dependence	33
4.3 Women: Structural Inequality and Opportunity Gaps	34
4.4 Children: Exposure, Labour, and Lost Futures	34
4.5 Causes of Vulnerability	35
4.6 Needs Assessment and Response Priorities	35
4.7 Outlook: From Vulnerability to Resilience	36
5. Women in Ghana and Inclusion Strategy	37
5.1 The Socio-Economic Context of Women in Ghana	37
5.2 Women and Environmental Degradation	38
5.3 The Business Case for Gender Inclusion	38
5.4 The Inclusion Strategy	38
6. Community Engagement and Adaption	41
6.1 The Importance of Community Participation	41
6.2 Perceptions of Industrial Hemp in Ghana	41
6.3 Communication Strategy	42
6.4 The Role of Traditional Authorities and Local Institutions	42
6.5 Youth Engagement and Knowledge Transfer	43
6.6 Community Adaptation to Environmental Change	44
6.7 Feedback and Grievance Mechanisms	44
6.8 Monitoring Social Acceptance and Behavioural Change	44
6.9 Expected Outcomes	45
6.10 Strategic Partnerships	45
7. Legal and Policy Feasibility	48
7.1 The Legal Status of Industrial Hemp in Ghana	48
7.2 Environmental Legislation and Land-Use Governance	48
7.3 Agricultural and Industrial Policy Environment	49
7.4 International Commitments and Legal Compatibility	49
7.5 Institutional Roles and Coordination	50
7.6 Regulatory Gaps and Risks	50
7.7 Policy Opportunities and Pathways Forward	51
7.8 Strategic Partnerships for Policy Alignment	51
8. Implementation Plan	53
8.1 Implementation Approach	53
8.2 Overall Objective	53
8.3 Project Phases	54
8.3.1 Phase 1: Preparatory and Research Stage (Months 1–12)	54
8.3.2 Phase 2: Pilot Implementation (Months 13–36)	54

8.3.3 Phase 3: Scale-Up and Policy Integration (Months 37–60).....	55
8.4 Governance and Institutional Framework	55
8.5 Implementation Timeline.....	56
8.6 Resource Requirements (Indicative).....	56
8.7 Risk Management and Mitigation.....	57
8.8 Monitoring, Evaluation, and Learning (MEL)	58
8.9 Sustainability and Exit Strategy	58
8.10 Expected Outcomes	58
9. Cost-Benefit and Financial Analysis	59
9.1 Methodological Framework.....	59
9.2 Baseline: The Cost of Inaction	59
9.3 Comparative Cost Analysis.....	60
9.4 Quantified Benefits	60
9.5 Cost–Benefit Ratio and Economic Return.....	61
9.6 Financial Sustainability	61
9.7 Sensitivity Analysis	62
9.8 Non-Monetary and Strategic Value.....	62
9.9 Conclusions.....	63
10. Risk Assessment.....	64
10.1 Overview of Risk Framework.....	64
10.2 Environmental and Technical Risks	64
10.3 Social and Community Risks	65
10.4 Policy and Regulatory Risks	66
10.5 Financial and Economic Risks	67
10.6 Health, Safety, and Environmental (HSE) Risks	67
10.7 Environmental and Social Safeguards	67
10.8 External and Climatic Risks	68
10.9 Risk Monitoring and Adaptive Management.....	68
10.10 Overall Risk Profile	69
10.11 Conclusion.....	69
11. Monitoring and Evaluation Framework.....	70
11.1 Purpose and Principles.....	70
11.2 Institutional Responsibilities.....	70
11.3 Monitoring Dimensions	71
11.4 Key Indicators and Targets.....	71
11.5 Data Collection and Verification.....	72
11.6 Evaluation Schedule	73
11.7 Learning and Knowledge Management	73
11.8 Feedback, Transparency, and Adaptive Management.....	74

11.9 Alignment with National and International Frameworks	74
11.10 Expected Outcomes of the MEL System	74
11.11 Conclusion.....	75
12. Communication and Dissemination Plan	76
12.1 Communication Objectives	76
12.2 Guiding Principles.....	76
12.3 Target Audiences	77
12.4 Communication Channels and Tools	77
12.5 Branding and Messaging	78
12.6 Stakeholder Engagement and Feedback Mechanisms	78
12.7 Communication Responsibilities	79
12.8 Phased Implementation of the Communication Plan.....	79
12.9 Risk Management in Communication	79
12.10 Monitoring and Evaluation of Communication	80
12.11 Expected Outcomes	80
12.12 Conclusion.....	80
13. Conclusion and Recommendations.....	81
13.1 Key Findings (Executive Summary).....	81
13.2 Synthesis and Overall Conclusion	82
13.3 Strategic Recommendations.....	82
13.4 Outlook and Next Steps.....	83
13.5 Final Statement	84
Annex: References and Supporting Literature	85
Scientific and Technical Studies on Industrial Hemp and Phytoremediation	85
Biochar and Phytoremediation Research.....	86
Policy, Legal and Strategic Frameworks.....	86
Summary Note	87

Foreword

Across the world, societies are confronting the legacy of environmental degradation and the urgent need to restore ecosystems damaged by unsustainable practices. In Ghana, artisanal and small-scale gold mining has long supported livelihoods but has also left behind a grave ecological burden. Mercury and arsenic contamination of soils and water bodies continue to threaten food security, biodiversity, and human health, particularly in the country's central and western regions. Addressing this challenge requires not only technological innovation but also cultural commitment, social inclusion, and institutional cooperation.

The DECON HEMP initiative was conceived as a response to this multidimensional problem.

It builds upon Ghana's leadership in nature-based and community-driven environmental strategies, seeking to demonstrate that rehabilitation of degraded land can go hand in hand with economic opportunity and social renewal. The feasibility study presented here explores the potential of industrial hemp (*Cannabis sativa L.*) and biochar to provide a safe, effective, and scalable means of remediating mercury- and arsenic-contaminated soils. Industrial hemp, a fast-growing and resilient crop, has been shown by international research to absorb and stabilize heavy metals while restoring soil structure and fertility. When combined with biochar, a carbon-rich material produced through controlled pyrolysis, this approach creates a circular process: pollutants are immobilized, soil carbon is replenished, and new employment opportunities emerge around biomass utilization and local value creation.

Key Messages

- **Why industrial hemp?** Because it unites environmental restoration with tangible social and economic returns — turning contaminated land into productive assets while generating green jobs, circular biochar industries, and verifiable carbon credits.
- **Why now?** Because Ghana stands at a decisive point: mercury pollution continues to expand while international demand for credible, nature-based carbon-removal projects and sustainable supply chains has never been stronger.
- **Why DECON HEMP?** Because it offers a tested, inclusive, and science-based roadmap that integrates phytoremediation, circular economy, and community livelihoods into one replicable model for Africa's green transition.

What makes DECON HEMP distinctive is its integration of science, governance, and cultural context.

The project concept acknowledges the essential role of traditional authorities and local leadership in environmental stewardship, and it is designed to work in close consultation with regional councils and community leaders in the Ashanti and other affected regions. By aligning scientific innovation with traditional values of responsibility toward the land, the initiative reflects Ghana's broader vision of a green and inclusive transition. It also demonstrates how collaborative governance — linking national institutions such as the Environmental Protection Agency (EPA), the Narcotics Control Commission (NACOC), and the Ministry of Environment, Science, Technology

and Innovation (MESTI) with local knowledge and international expertise — can produce solutions that are both effective and culturally grounded.

The study has been developed by the German Federal Association for Sustainability and the Linnaeus Competence Center Hemp, reflecting a growing international commitment to share knowledge and technology for sustainable transformation.

Beyond its immediate environmental objectives, DECON HEMP represents a new economic paradigm.

By replacing destructive extraction with regenerative cultivation, it redefines the relationship between communities and their environment. The project envisions creating dignified green jobs, particularly for women and young people, who will be trained in sustainable land management, biochar production, and environmental monitoring. It transforms contaminated sites into laboratories of innovation, where scientific validation, vocational training, and community empowerment reinforce one another.

This feasibility study therefore represents more than a technical assessment; it is a blueprint for a different kind of development — one that restores balance between economy, ecology, and culture. It draws on the most recent scientific evidence, aligns with Ghana's national climate and biodiversity policies, and directly contributes to the Sustainable Development Goals, particularly SDGs 3, 5, 8, 12, 13, and 15. Its results provide a foundation for pilot implementation and for positioning Ghana as a pioneer in the use of industrial hemp and biochar for environmental remediation in Africa.

We express our gratitude to the many partners, scientists, and communities who supported this study. Their engagement ensures that DECON HEMP is not only scientifically credible but also socially grounded and nationally relevant. It is our collective hope that this initiative will inspire similar efforts across the continent, demonstrating that through innovation, cooperation, and respect for nature, even the most degraded landscapes can become sources of renewal and prosperity.

Berlin (Germany), October 2025



Martin Wittau
President
German Federal Association for Sustainability



Tarik Mustafa
CEO
Linnaeus Competence Center Hemp

Acknowledgement

The editors wish to express their sincere appreciation to

Mr. George Boakye Sarpong
Chief Executive Officer of
African Golden Food Ltd. (AGF),

whose vision and initiative first brought attention to the link between illegal gold mining, environmental pollution, and the loss of livelihoods in Ghana's mining regions.

During early discussions on the potential of industrial hemp for sustainable agriculture and materials innovation, Mr. Sarpong introduced the idea of exploring its capacity for decontaminating soils affected by mercury and arsenic, which ultimately inspired the development of the DECON HEMP feasibility study.

African Golden Food Ltd., as outlined in the Consortium Agreement with Linnaeus Kompetenzzentrum Hanf gGmbH, Revita Hanfkontor GmbH, and the Bundesvereinigung Nachhaltigkeit e.V., has played a central role in identifying field realities, highlighting community needs, and ensuring that future project phases remain grounded in Ghana's social and environmental priorities.

While AGF did not participate in the drafting or technical preparation of this feasibility study, its conceptual contribution and early engagement were instrumental in defining the study's direction. The editors therefore gratefully acknowledge Mr Sarpong's commitment to sustainable development and his continuing efforts to advance collaborative, nature-based solutions for Ghana's green transformation.

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.

The Linnaeus Competence Center Hemp

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, soil science, materials research, and circular-economy design. Linnaeus develops future-oriented training programs and applied research models that link industrial hemp cultivation with environmental restoration, carbon management, and sustainable industrial transformation. The institute's work integrates academic research with vocational education and international cooperation, ensuring that hemp-based innovation contributes to climate action, decent work, and green economic development.

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

The German Federal Association for Sustainability

The German Federal Association for Sustainability (Bundesvereinigung Nachhaltigkeit, BVNG) is an umbrella non-profit organization that has, since 2013, been engaged in Vocational Education and Training for Sustainable Development (BBNE), European cooperation projects, and sustainability policy. BVNG supports small and medium-sized enterprises (SMEs) and partner institutions in adapting to the twin challenges of green transformation and skills shortages. With more than 600 companies reached to date, BVNG designs and manages projects funded by the EU, the German government, and international donors, developing innovative tools and networks that integrate sustainability principles into professional and regional development.

<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 **DECON HEMP** is both scientifically grounded and socially inclusive—linking environmental remediation with skills development, sustainable entrepreneurship, and circular-economy innovation.

Through their partnership, Linnaeus and BVNG aim to translate the lessons from DECON HEMP into new vocational curricula, policy recommendations, and investment models that support Ghana's and Africa's green transition in line with the UN Sustainable Development Goals, the Paris Agreement, and the African Union's Green Recovery Action Plan.

Executive Summary

This feasibility study presents the concept, scientific foundation, and socio-economic rationale of the **DECON HEMP** Initiative, a Ghana-based program designed to rehabilitate mercury and arsenic-contaminated mining lands through the combined application of industrial hemp (*Cannabis sativa L.*) and biochar technology.

The project responds to the growing environmental and public-health risks posed by artisanal and small-scale gold mining (ASM) while creating new livelihood opportunities and contributing to Ghana's transition toward a circular, low-carbon economy.

Mercury and arsenic pollution from ASM activities has affected thousands of hectares of productive land, degraded water quality, and endangered communities across the Ashanti, Western, and Eastern Regions. Conventional soil-remediation methods are prohibitively expensive, technically demanding, and socially disruptive. DECON HEMP therefore proposes an alternative approach — one that relies on nature-based, inclusive, and economically viable solutions that integrate scientific validation, local participation, and international cooperation.

Scientific and Technical Rationale

Industrial hemp is a fast-growing, deep-rooted crop with remarkable tolerance to soil contaminants.

Recent research confirms its ability to absorb, immobilize, and stabilize heavy metals including mercury (Hg) and arsenic (As). Field and laboratory studies conducted between 1988 and 2023 demonstrate measurable uptake of these metals and up to 60 percent reductions in their mobility when industrial-hemp cultivation is combined with biochar soil amendments (e.g. Kumar et al., 2022; Güler & Zengin, 2022). The scientific mechanism involves both **phytoextraction** (absorption and storage of metals in plant tissues) and **phytostabilization** (immobilization within the root zone). Complementary studies further indicate that plants can biologically transform ionic mercury into less toxic elemental forms, supporting the theoretical basis for hemp-based detoxification. The addition of biochar, a carbon-rich by-product of controlled biomass pyrolysis, enhances remediation performance by binding residual metals, increasing cation-exchange capacity, and improving soil structure.

Together, **industrial hemp and biochar form a closed-loop system**: the plant removes and stabilizes pollutants, while the converted biomass sequesters carbon and safely locks contaminants into inert matrices. This dual function directly supports climate-change mitigation, land restoration, and sustainable rural employment.

Project Objectives and Approach

DECON HEMP has four interconnected objectives:

1. Environmental Restoration

Remediate and stabilize mercury and arsenic-contaminated soils and improve water quality in affected mining areas.

2. **Scientific Validation**

Generate the first Ghana-specific dataset on heavy-metal phytoremediation and biochar-assisted stabilization under tropical conditions.

3. **Socio-Economic Transformation**

Create green jobs and alternative income for artisanal-mining communities, especially for women and youth, through cultivation, processing, and environmental services.

4. **Policy and Knowledge Integration**

Embed lessons learned into national frameworks for climate action, vocational education, and sustainable-resource governance.

The project is structured around collaboration between Ghanaian institutions and other entities — principally the Environmental Protection Agency (EPA), the Narcotics Control Commission (NACOC), the Ministry of Environment, Science, Technology and Innovation (MESTI), and African Golden Food Ltd. — and international partners, notably the German Federal Association for Sustainability (BVNG) and the Linnaeus Competence Center Hemp. Implementation will occur in phases: baseline soil and water analysis, pilot-site establishment, cultivation cycles with monitoring, and evaluation leading to large-scale replication.

Economic and Social Viability

Cost–benefit analysis demonstrates strong economic justification. Industrial-hemp remediation costs between USD 30 000–45 000 per hectare, about 70–80 percent cheaper than conventional mechanical or chemical alternatives. Over a **ten-year analytical horizon** (five-year pilot plus five years of sustained impact) and a 6 percent discount rate, total discounted benefits are estimated at USD 23–24 million against costs of USD 12 million, producing a Net Present Value (NPV) of USD 7.5–8 million and a Benefit–Cost Ratio of $\approx 2 : 1$.

Economic benefits derive from four streams:

- employment and enterprise creation in cultivation, processing, and biochar production;
- restored land productivity and ecosystem services;
- monetized carbon sequestration ($\approx 5\,000\text{ t CO}_2$ over five years); and
- reduced public-health costs through lower exposure to toxic metals.

Socially, DECON HEMP can generate at least **500 direct and 2 000 indirect jobs**, with a commitment that 50 percent of beneficiaries are women. Training programs will build vocational skills in sustainable agriculture, pyrolysis technology, and environmental monitoring. The initiative will thus help communities shift from extractive livelihoods to restorative ones—linking economic security with ecological stewardship.

Policy, Legal, and Institutional Context

The project operates fully within Ghana’s regulatory framework. The Narcotics Control Commission Act (Act 1019) authorizes industrial-hemp cultivation for research and industrial use under controlled conditions, while the Environmental Protection Agency Act (Act 490) governs environmental licensing and waste management. The initiative directly supports the National Climate Change Policy, the Green Ghana Initiative, and the Medium-Term Development Policy Framework. At the international level, DECON HEMP aligns with the UN Sustainable

Development Goals (SDGs 3, 5, 8, 12, 13, 15), the Paris Agreement, and the African Union Green Recovery Action Plan 2021–2027.

Expected Outcomes

By the end of its five-year pilot phase, DECON HEMP aims to deliver:

- Verified reductions of 40–60 percent in Hg and As mobility on pilot sites;
- A tested protocol for integrating industrial hemp and biochar into national remediation standards;
- A trained local workforce and certified vocational curriculum in green-remediation technologies;
- A functional Phytoremediation Fund to channel carbon-credit and ESG financing into restoration projects;
- Enhanced community awareness and acceptance of industrial hemp as a legal, sustainable, and beneficial crop.

The project's Monitoring and Evaluation Framework (Chapter 11) establishes environmental, social, and financial indicators to ensure transparency and adaptive learning. Quarterly reporting and external evaluation will generate publicly accessible data for replication across West Africa.

Strategic Significance

DECON HEMP combines scientific credibility, economic realism, and cultural relevance. It transforms contaminated landscapes into productive, climate-positive assets and demonstrates how environmental remediation can catalyse inclusive growth. The initiative strengthens Ghana's standing as a regional leader in circular, nature-based solutions and provides a replicable model for other African nations facing similar post-mining challenges.

In a global context of rising demand for high-integrity carbon removals and sustainable materials, DECON HEMP represents a timely and scalable innovation—proof that environmental restoration and economic transformation can advance together. The study concludes that the proposed approach is technically feasible, economically viable, socially inclusive, and institutionally ready for implementation.

Main Conclusions

1. Scientific Feasibility

Industrial hemp (*Cannabis sativa L.*) has proven tolerance to heavy-metal contamination and the capacity to absorb and stabilize mercury (Hg) and arsenic (As) in mining-affected soils. Combined with biochar, the system achieves 40–60% reductions in Hg and As mobility, while improving soil structure and fertility.

2. Innovative Dual Approach

The integrated industrial hemp–biochar model functions as both a remediation tool and a circular-economy process. Contaminants are extracted or immobilized through plant and soil mechanisms, while biochar production sequesters carbon and safely encapsulates captured metals.

3. Economic Efficiency

Estimated remediation costs of USD 30 000–45 000 per hectare are 70–80% lower than conventional chemical or mechanical methods. Over a 10-year horizon, total discounted benefits of USD 23–24 million against costs of USD 12 million yield a Net Present Value (NPV) of USD 7.5–8 million and a Benefit–Cost Ratio of $\approx 2 : 1$.

4. Climate and Environmental Benefits

Each hectare of industrial hemp can sequester 10–15 t CO₂ annually, contributing to an estimated 5 000 t CO₂ offset over the pilot phase. Additional gains include improved biodiversity, reduced erosion, and cleaner water systems.

5. Social Inclusion

The project creates 500 direct and 2 000 indirect jobs, with a minimum 50% female participation. Training in green skills, biochar production, and environmental monitoring supports youth employment and gender equity in transition economies.

6. Legal and Policy Readiness

The initiative operates fully under Ghana's Narcotics Control Commission Act (Act 1019) and EPA Act 490, aligning with the National Climate Change Policy, Green Ghana Initiative, and SDGs 3, 5, 8, 12, 13 and 15.

7. Institutional Collaboration

DECON HEMP connects Ghanaian agencies and entities (EPA, NACOC, MESTI, AGF) with international partners — the German Federal Association for Sustainability (BVNG) and the Linnaeus Competence Center Hemp — ensuring scientific rigor, governance, and vocational-education integration.

8. Community and Cultural Anchoring

The project framework emphasizes partnership with regional councils and traditional authorities, integrating local knowledge and stewardship values into sustainable land management.

9. **Scalability and Replication**

The pilot will produce Ghana's first verified dataset on Hg/As phytoremediation under tropical conditions, a transferable methodology for other West African mining regions, and a training and financing model that links restoration with carbon markets.

10. **Overall Conclusion**

DECON HEMP is technically feasible, economically efficient, socially inclusive, and policy-ready. It offers Ghana a credible, science-based pathway to transform contaminated mining lands into engines of sustainable growth and climate resilience.

1. Background

Ghana faces severe environmental degradation caused primarily by artisanal and small-scale mining (galamsey), resulting in widespread soil and water contamination with heavy metals. Conventional remediation is costly and inaccessible for most affected communities. Industrial hemp offers a sustainable, low-cost solution capable of restoring soil fertility and creating equitable livelihoods. This chapter contextualizes the problem and outlines the purpose and scope of the DECON HEMP feasibility study.

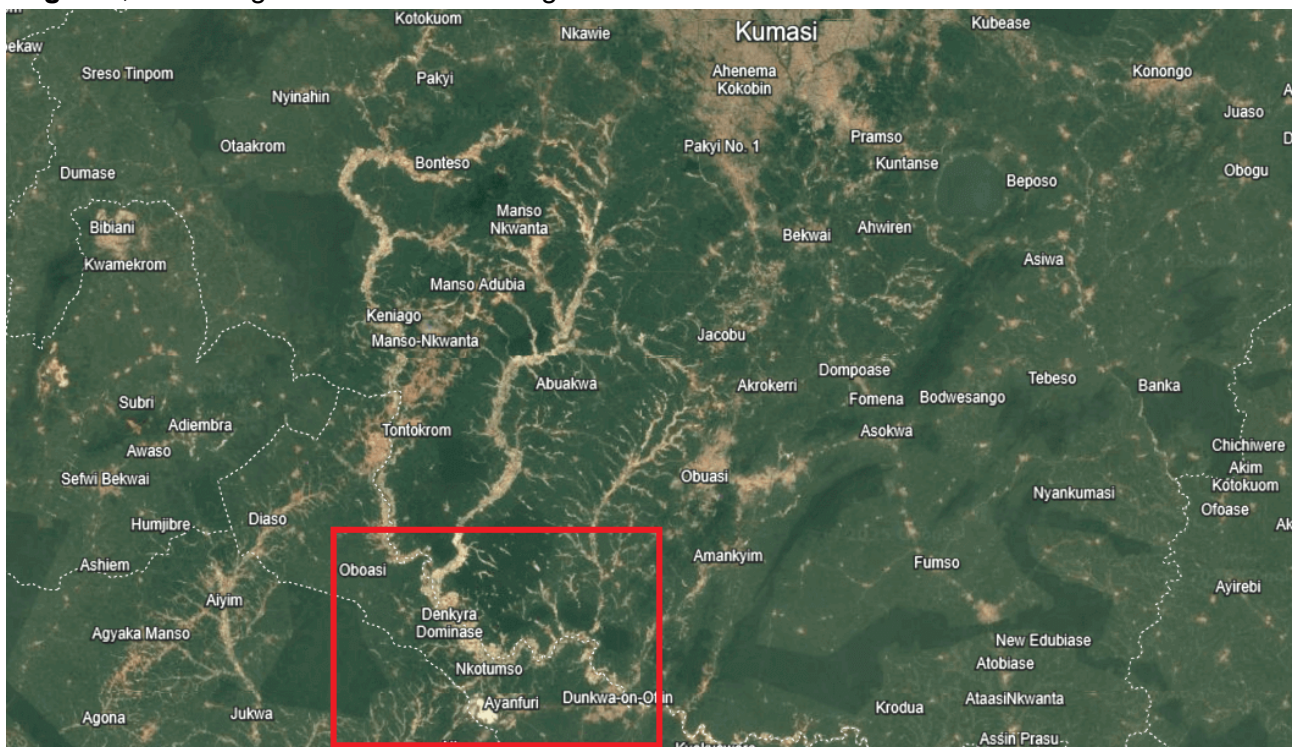
1.1 Overview of Environmental Contamination in Ghana

Ghana's mining sector—particularly artisanal and small-scale gold mining (ASM)—has produced significant ecological degradation and widespread heavy-metal pollution. More than 77,000 hectares of farmland have been degraded, and mercury (Hg), arsenic (As), lead (Pb), and cadmium (Cd) now contaminate soils, rivers, and groundwater in mining zones.

Other contributing factors—such as e-waste dumping, deforestation, poor sanitation, and industrial discharge — further exacerbate these impacts, threatening biodiversity, food security, and public health. Climate stressors such as rising mean temperatures, irregular rainfall, and declining soil moisture amplify these challenges and reduce ecosystem resilience, particularly in the forest-savannah transition zones.

Mapping of Contamination Hotspots

The spatial distribution of contamination in Ghana (Image 1) highlights the heaviest concentration of degraded land and heavy-metal pollution across the **Western, Ashanti, Eastern, and Central Regions**, which align with Ghana's main gold belts—the *Birimian* and *Tarkwaian* formations.



Illegal mining areas Southwest of Kumasi - all yellow areas alongside rivers (Google Earth)



Zoom in: Illegal mining areas Southwest of Kumasi, alongside Offin River (Google Earth)

These belts host dense ASM activity responsible for releasing mercury, arsenic, cadmium, and lead into soils and water bodies. The mapping, created for this study, is consistent with national and academic sources identifying the same regional trends (Hilson et al., 2021; Adjei et al., 2023; Bansah et al., 2024; EPA Ghana, 2022).

1.2 Problem Statement

Illegal and poorly regulated mining has created a dual crisis of environmental degradation and socio-economic vulnerability. Toxic metals enter water and food chains, damaging ecosystems and human health.



Conventional remediation methods — such as excavation, chemical stabilization, and soil washing — are expensive, disruptive, and rarely accessible to rural communities. These approaches often fail to restore ecological functionality or productive land use¹. There is an urgent need for a cost-effective, community-driven, and sustainable method that addresses contamination while simultaneously improving livelihoods. According to the Environmental Protection Agency (EPA) of Ghana, pollution from these sources has led to declining agricultural productivity and unsafe living conditions in numerous regions.²

The environmental impacts are compounded by climate stress, such as increasing temperatures, drought risk, and declining soil moisture, particularly in the northern and transitional zones. These stressors reduce the resilience of affected ecosystems and communities, making remediation efforts more urgent and complex.

1.3 Study Goal

The DECON HEMP study assesses the feasibility of **using industrial hemp (*Cannabis sativa* L.) to remediate heavy-metal-contaminated soils** in Ghana's mining regions. It aims to:

¹ U.S. Environmental Protection Agency. (2008, April 10). Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites (EPA 542-R-08-002). U.S. EPA. Retrieved from <https://www.epa.gov/sites/default/files/2015-04/documents/green-remediation-primer.pdf>

² United Nations Development Programme. (2021, December). Environment and Climate Change in Ghana: Policy Brief. United Nations Development Programme.

- **Restore**
soil fertility and re-value degraded mining land;
- **Reclaim**
land for affected communities and advance environmental justice;
- **Empower**
women and marginalized groups through participation in hemp-based value chains;
- **Integrate**
phytoremediation into Ghana's sustainable agriculture, land-use, and climate policies.

This approach aligns with national frameworks such as the National Climate Change Policy (NCCP), REDD+ Strategy, and Ghana's Nationally Determined Contributions (NDCs) under the Paris Agreement.

1.4 Scope of the Study / SDGs Alignment

This feasibility study provides a comprehensive analysis of industrial hemp as a phytoremediation crop within Ghana's environmental, social, and policy contexts. It covers:

- The scientific and technical basis for hemp-based remediation;
- Environmental, social, and economic implications of contamination and cleanup;
- Gender and community engagement strategies;
- The legal and policy framework for industrial hemp cultivation;
- A detailed implementation plan, resource assessment, and risk analysis.

Drawing on international case studies and local expertise, DECON HEMP proposes a scalable model for environmentally and socially sustainable remediation aligned with the UN Sustainable Development Goals:

SDG	Goal Title	How DECON HEMP Contributes
SDG 1 – No Poverty	End poverty in all its forms everywhere	Creates local employment and income streams through hemp cultivation, processing, and environmental service contracts for rural communities affected by mining.
SDG 2 – Zero Hunger	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture	Restores degraded farmland for future food production and promotes regenerative soil practices.
SDG 3 – Good Health and Well-being	Ensure healthy lives and promote well-being for all	Reduces exposure to toxic metals, lowering chronic disease risks in mining communities.
SDG 5 – Gender Equality	Achieve gender equality and empower all women and girls	Integrates women into value chains, secures land access, and provides training and credit opportunities.

SDG 8 – Decent Work and Economic Growth	Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work	Creates green jobs and new microenterprises in hemp-based industries and phytoremediation services.
SDG 9 – Industry, Innovation and Infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation	Promotes innovation in bio-based industries, environmental engineering, and low-carbon technologies.
SDG 12 – Responsible Consumption and Production	Ensure sustainable consumption and production patterns	Encourages circular economy practices through biomass valorization and safe reuse pathways.
SDG 13 – Climate Action	Take urgent action to combat climate change and its impacts	Contributes to carbon sequestration, reduces emissions through biofuels and biochar, and restores climate resilience.
SDG 15 – Life on Land	Protect, restore, and promote sustainable use of terrestrial ecosystems	Restores degraded land and enhances biodiversity through sustainable phytoremediation.
SDG 17 – Partnerships for the Goals	Strengthen the means of implementation and revitalize the global partnership for sustainable development	Builds multi-stakeholder partnerships among government, academia, NGOs, and local communities for co-governed remediation projects.

2. Scientific and Technical Basis

This chapter outlines the scientific foundation and technical rationale of DECON HEMP, focusing on the capacity of **industrial hemp (*Cannabis sativa* L.)** to remediate heavy-metal-contaminated soils in mining-affected regions. It explains phytoremediation mechanisms, evaluates biomass valorization options, compares industrial hemp to other remediation methods, and examines its sustainability under Ghanaian environmental conditions. The chapter also reviews relevant case studies and explores the complementary role of **biochar** in waterlogged or non-plantable areas. Together, these elements form the scientific backbone for pilot implementation.

Industrial hemp, supported by biochar technology, represents a scientifically robust, economically viable, and socially inclusive strategy for remediating mercury and arsenic-contaminated soils. Its mechanisms of action are well understood, its performance is empirically supported by recent international studies, and its adaptability to Ghana's agroclimatic context is clear.

DECON HEMP therefore stands on a strong technical foundation to become a demonstration model for sustainable remediation and circular bioeconomy innovation in West Africa.

2.1 Mechanisms of Phytoremediation

Phytoremediation is a set of plant-based technologies that use living vegetation to remove, stabilize, or detoxify contaminants in soil and water. Industrial hemp has emerged as a particularly promising species due to its rapid growth, high biomass, deep root system, and tolerance to heavy metals.

The primary mechanisms relevant to DECON HEMP are:

1. **Phytoextraction**

Industrial hemp absorbs heavy metals from the soil through its roots and translocates them to above-ground tissues (stems and leaves). The metals are then safely harvested with the biomass, removing contaminants from the site.

2. **Phytostabilization**

In areas with high contamination, hemp's extensive root network immobilizes metals within the rhizosphere, reducing their bioavailability and leaching potential. This process is crucial for highly polluted mining tailings where full extraction is not feasible.

3. **Rhizofiltration**

Industrial hemp roots can absorb or adsorb metals from contaminated water or shallow groundwater, contributing to the purification of runoff and irrigation systems.

4. **Phytovolatilization**

Some plant species can transform metals into gaseous forms; mechanistic studies (Rugh et al., 1996) demonstrated that plants can enzymatically reduce ionic mercury (Hg^{2+}) to elemental mercury (Hg^0). Although hemp-specific pathways are still under study, preliminary observations indicate similar detoxification mechanisms may occur.

Recent literature confirms that industrial hemp is capable of accumulating mercury (Hg) and arsenic (As) alongside cadmium (Cd), lead (Pb), and zinc (Zn).

- *Siegel et al. (1988)* first documented Hg uptake in cannabis from geothermal soils.
- *Altmaier (2021)* verified trace Hg and As presence in industrial hemp cultivars via ICP-MS analysis.
- *Güler & Zengin (2022)* and *Kumar et al. (2022)* demonstrated both phytoextraction and phytostabilization of Hg and As under field and greenhouse conditions.
- The *2023 Biochar–Industrial Hemp* study showed 40–60 % reductions in Hg and As mobility when biochar was applied concurrently.

These findings confirm that industrial hemp offers a **dual function**: extraction where contamination levels permit and stabilization where toxicity inhibits full uptake. This hybrid capacity is the scientific foundation for DECON HEMP's pilot approach in Ghana's mercury-affected artisanal-mining landscapes.

2.2 Phytomining and Biomass Valorization

Phytomining refers to recovering valuable elements or mitigating toxic metals from plants after they accumulate in their tissues³. For DECON HEMP, the biomass produced through remediation is both a resource and a potential hazard, depending on its contaminant content.

Safe Biomass Handling and Transformation

Industrial hemp biomass harvested from contaminated soils must be processed carefully:

- **Controlled Pyrolysis**
Conversion into biochar at ≥ 500 °C immobilizes metals within carbon matrices and prevents re-emission of volatile mercury.
- **Gas-Capture Systems**
Activated-carbon filters or condensation traps should be used to capture Hg vapours.
- **Ash Management**
Post-pyrolysis residues can be stabilized or vitrified for secure storage.

Value-Added Utilization

Even contaminated industrial hemp can generate economic value through safe applications:

- **Biochar and Carbon Products**
Clean or low-contaminant biomass can be used to produce biochar, bio-oil, or activated carbon for water treatment.
- **Industrial Uses**
Stalks from non-contaminated sites can supply fibre for textiles, paper, or construction materials (hempcrete).
- **Energy Recovery**
Residual bio-oil from pyrolysis can contribute to renewable energy generation.

³ See: Jure Voglar, Anže Prašnikar, Konstantin Moser, Elisa Carlon, Manuel Schwabl, Blaž Likozar, Pyrolysis of industrial hemp biomass from contaminated soil phytoremediation: Kinetics, modelling transport phenomena and biochar-based metal reduction, *Thermochimica Acta*, Volume 742, 2024, <https://doi.org/10.1016/j.tca.2024.179899>

Thus, phytomining in DECON HEMP is not limited to metal extraction; it integrates circular-economy principles — transforming waste into safe, productive materials.

2.3 Limitations of Industrial Hemp for Phytoremediation

While industrial hemp exhibits robust tolerance to multiple contaminants, several limitations affect its efficiency:

- 1. **Variability in Uptake**
Metal accumulation depends strongly on soil pH, redox potential, organic matter, and metal speciation. Arsenic, in particular, is less bioavailable in neutral to alkaline soils.
- 2. **Shallow Metal Redistribution**
Most metals concentrate in root and lower-stem tissues, limiting extraction yield unless multiple harvests are conducted.
- 3. **Mercury Volatility**
Some absorbed Hg may volatilize, complicating mass-balance assessment and requiring gas monitoring during pyrolysis.
- 4. **Climatic Dependence**
Optimal performance occurs under warm, moderately humid conditions; extreme droughts or flooding can suppress biomass and microbial activity.
- 5. **Regulatory Constraints**
Industrial hemp cultivation for environmental use still requires strict compliance with Ghana’s Act 1019, including THC-content monitoring and secure site fencing.

Recent studies (Kumar et al., 2022; Biochar–Industrial Hemp 2023) show that co-application of biochar and beneficial microbial consortia mitigates many of these limitations by improving soil pH, nutrient balance, and microbial diversity—enhancing both uptake and stability.

2.4 Comparative Analysis

The overarching objective of soil remediation is to achieve a protective final solution for both human health and the environment. Selecting the appropriate remediation technique is paramount, requiring careful consideration of contaminant type, site characteristics, cost, environmental footprint, and the desired cleanup duration. Soil remediation methodologies are broadly categorized into physical, chemical, and biological approaches, with combined or integrated methods increasingly gaining traction. These techniques can be applied either in situ (treating contamination at its original location) or ex-situ (excavating and treating material elsewhere). In situ methods generally involve less land disturbance and can be more cost-effective for large-scale contamination, while ex-situ methods offer greater control and can yield quicker results in specific scenarios.

Remediation Method	Description	Primary Contaminants Addressed	Advantages	Limitations
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Physical				
Capping	Placing layers of clean or reactive material over contaminated areas as a physical barrier.	Various, primarily sediments.	Non-intrusive, cost-effective for large areas, reduces contaminant mobility.	Unsuitable for shallow water for high water flows; does not remove contaminants; long-term monitoring required.
Soil Washing	Ex situ technique where contaminated soil is mixed with an aqueous solution to transfer pollutants from soil to the solution.	Weakly associated contaminants in coarse-grained sediments, heavy metals.	Effective for certain soil types; reduces contaminant concentration.	Produces contaminated wastewater requiring further treatment; does not completely remove contaminants; less effective for fine-grained soils.
Excavation	Physical removal of highly contaminated soil.	Wide range of contaminants, highly concentrated pollution.	Immediate restoration; high security; offers quick results.	Very expensive; generates significant waste requiring disposal; applicable only for small areas; disruptive to the ecosystem.
Thermal Desorption	Uses heat to volatilize contaminants into a gas phase, requiring off-gas treatment.	Petroleum hydrocarbons, volatile organic compounds.	Highly effective for organic contaminants; fast remediation.	Not suitable for metal contaminants; high energy consumption; generates air emissions requiring treatment; complex operation.
Vapor Extraction	Uses vacuum technology to remove volatile organic compounds from the subsurface.	Volatile organic compounds, hydrocarbons.	Effective for specific volatile contaminants; in situ application.	Limited to volatile compounds; effectiveness depends on soil permeability; potential for air emissions.
Remediation Method	Description	Primary Contaminants Addressed	Advantages	Limitations
Chemical				
Immobilization/Stabilization	Aims to reduce the mobility, toxicity, and bioavailability	Heavy metals.	Cost-effective for heavy metal sites; reduces mobility	Does not remove contaminants; treated land may lose

	of heavy metals by altering them into more geo-chemically stable phases (absorption, complexation, precipitation).		and bioavailability; can be in situ.	ecological functions; long- term integrity concerns.
Solidification	Physically encapsulates contaminants in a solid matrix using binders (cement, bitumen, fly ash).	Heavy metals, various hazardous wastes.	Quick; highly efficacious; imparts physical stability.	Does not extract pollutants; treated land loses ecological functions; long-term integrity concerns; increases volume of contaminated material.
Vitrification	Uses high thermal energy (1400-2000°C) to melt soil into an amorphous glass, encapsulating contaminants.	Wide range of contaminants, including heavy metals and radionuclides.	Highly efficient; permanent immobilization.	Extremely expensive; highly complex to perform; very high energy consumption.
Electrokinetic Remediation	Applies an electric field to wet contaminated sediments, moving ionized metals towards electrodes.	Heavy metals, polar organic contaminants in fine-grained soils.	Efficient in fine-grained clayey soil; in situ application.	High energy consumption; limited to soluble ions; complex operation; electrode maintenance.
In Situ Oxidation	Injects strong oxidants (e.g., hydrogen peroxide, ozone) to degrade pollutants.	Organic contaminants, petroleum hydrocarbons.	Effective for a wide range of organic pollutants; in situ application.	Can be costly; potential for secondary reactions or incomplete degradation; requires careful monitoring.
Soil Flushing	Uses water or chemical solutions to accelerate contaminant mobilization, followed by recovery and treatment of fluids.	Various contaminants, particularly in permeable soils.	Can be effective for soluble or desorbable contaminants; in situ application.	Produces contaminated wastewater requiring treatment; less effective for strongly adsorbed contaminants; may alter soil properties.

Remediation Method	Description	Primary Contaminants Addressed	Advantages	Limitations
Biological (Bioremediation)				
Phytoremediation	Uses plants to reduce or remove contaminants from soil.	Heavy metals, organic pollutants (hydrocarbons).	Eco-friendly; cost-effective (60-80% less than traditional methods); does not interfere with natural soil functions; provides additional benefits (carbon sequestration, erosion control, biodiversity).	Slow process (months to years); risk of bioaccumulation if not properly disposed; restricted to specific metals; effectiveness depends on growth conditions and bioavailability; large land area required.
Microbial Remediation	Uses microorganisms (bacteria, fungi, algae) to transform or remove contaminants.	Heavy metals, organic pollutants (hydrocarbons).	Eco-friendly; cost-effective; preserves natural soil microflora.	Success is highly dependent on environmental factors (temperature, pH, nutrients); not all contaminants are amenable; can be slow; requires specific conditions.
Combined /Integrated Methods	Utilizes more than one technique to leverage strengths and mitigate weaknesses.	Various contaminants.	High removal efficiency; shorter cleanup duration; moderate remediation cost; low environmental impact (compared to single methods).	Can be more complex to design and implement; requires careful coordination of different technologies.

Method	Cost (USD/ha)	Efficiency	Advantages	Limitations
Chemical stabilization	250 000–350 000	High (immediate immobilization)	Fast; proven	High cost; secondary waste generation

Physical excavation & replacement	200 000–300 000	High (complete removal)	Rapid site clearance	Carbon intensive; destroys soil ecology
Industrial hemp phytoremediation	30 000–45 000	Moderate (20–60 % reduction per cycle)	Low-cost, eco-friendly, creates jobs	Slower; requires multi-cycle management
Industrial hemp + biochar system	35 000–50 000	High (40–60 % reduction per cycle; stability increase)	Carbon sequestration; safer biomass handling	Requires technical oversight for pyrolysis

The comparative analysis confirms that **industrial hemp-based systems** provide the best balance between environmental performance, social benefits, and financial feasibility. Their slower remediation pace is offset by co-benefits such as job creation, soil health restoration, and ecosystem services—factors not captured in conventional cost accounting.

2.5 Sustainability and Suitability for Ghana

Ghana’s artisanal and small-scale gold mining (ASM) sector has created widespread mercury and arsenic contamination, particularly in the Ashanti, Western, and Eastern Regions. These areas suffer from soil infertility, polluted waterways, and declining agricultural productivity.

Industrial hemp offers an adaptable, climate-resilient crop that aligns with Ghana’s agroecological conditions:

- Grows effectively between 25–35 °C with moderate rainfall.
- Requires minimal fertilizer input and supports microbial recovery.
- Provides high biomass yield even in moderately contaminated soils.
- Stabilizes eroded land and prevents sediment runoff into rivers.

The approach complements Ghana’s National Climate Change Policy, Green Ghana Initiative, and Medium-Term Development Framework, promoting nature-based restoration and green job creation.

In the Ghanaian context, DECON HEMP’s implementation would not only restore degraded lands but also replace hazardous informal mining with safe, sustainable economic alternatives for local communities.

2.6 Case Studies of Industrial Hemp and Phytoremediation

Hemp has been used in several case studies to demonstrate its effectiveness in phytoremediation, a process that uses plants to clean up contaminated soil and water.

- **Chernobyl, Ukraine (Struik et al. 2000, McCutcheon et al. 2003)**
Industrial hemp successfully reduced radioactive cesium and strontium, demonstrating tolerance to extreme contamination.

- **Italy (Parisi et al. 2020)**
Hemp cultivation on industrially polluted soils led to >70 % reduction of Cd and Pb concentrations within several cycles (Biochar–Industrial Hemp 2023 summary).
- **China (Zhou et al. 2021)**
Industrial hemp grown on mining waste showed strong root uptake of Hg and Pb and improved microbial diversity.
- **Eastern Europe (Angelova et al., 2004)**
Multi-year trials confirmed Pb, Cd, and Zn accumulation in hemp biomass without yield reduction.
- **Recent Biochar Integration Trials (Kumar et al. 2022, Sward et al. 2025)**
Co-application of biochar and industrial hemp achieves measurable immobilization of mercury, arsenic, and other heavy metals, introducing a safe and scalable remediation model.

These case studies demonstrate that industrial hemp performs effectively across climatic zones and contamination profiles, reinforcing its suitability for Ghana’s pilot program.

2.7 Complementary Use of Biochar for Water and Non-Plantable Areas

Not all contaminated zones are suitable for direct cultivation. In waterlogged pits or highly toxic soils, biochar serves as a complementary remediation medium.

Applications

1. **Reactive Barriers and Filters**
Biochar layers trap dissolved mercury and arsenic in runoff water, reducing migration into rivers and groundwater.
2. **Wetland Integration**
In combination with local wetland vegetation, biochar enhances microbial activity and supports long-term water quality recovery.
3. **Soil Amendment**
When mixed into highly degraded soils, biochar improves structure, nutrient retention, and pH balance, creating conditions where industrial hemp can later be introduced.

Scientific Basis

Studies (Ahmad et al., 2014; Kumar & Sharma, 2020; Güler & Zengin, 2022; Kumar et al., 2022; Sward et al., 2025) demonstrate that biochar’s porous structure and oxygenated functional groups form stable complexes with Hg and As ions, decreasing their solubility and leaching risk by up to ≈60 %.

This dual-use strategy, **industrial hemp for phytoextraction and biochar for immobilization**, ensures comprehensive site rehabilitation, addressing both terrestrial and aquatic contamination pathways.

3. Social, Health and Economic Impact Assessment

This chapter evaluates the multi-dimensional impacts of implementing industrial hemp-based phytoremediation in Ghana's mining-affected regions. It examines the social and demographic characteristics of communities exposed to contamination, the public-health implications of heavy-metal pollution, and the potential of the DECON HEMP project to generate equitable livelihoods, gender inclusion, and long-term economic regeneration. The analysis draws on Ghanaian socio-economic data, international research on mining-community resilience, and projected benefits of nature-based restoration initiatives.

3.1 Social Impact

Illegal and poorly regulated artisanal and small-scale mining (ASM, or *galamsey*) has profoundly transformed the social fabric of many Ghanaian rural communities. Once anchored in subsistence farming and small-scale cocoa cultivation, these areas now experience population displacement, family fragmentation, and the erosion of traditional livelihoods. In towns across the Western, Ashanti, and Eastern Regions, the influx of migrant miners has produced rapid demographic changes. Local governance systems — customary land administration, chieftaincy, and community decision-making — have weakened under the pressure of economic opportunism and corruption.

The resulting instability contributes to a cycle of poverty, inequality, and social insecurity⁴. Families often lose their farmland to illegal mining operations, forcing youth and women to seek precarious employment in informal gold processing, trading, or support services⁵. Child labour in mining has become pervasive: the International Labour Organization (ILO) estimates that tens of thousands of children in Ghana engage in hazardous tasks associated with ASM, including ore washing and mercury handling.

The introduction of industrial hemp cultivation for soil restoration could reverse several of these dynamics. Industrial hemp farming is labour-intensive but safer than mining, and it promotes a settled, community-based production model. By allocating remediated plots to local cooperatives and women's groups, DECON HEMP can encourage resettlement of displaced farmers, restore land tenure security, and re-establish social cohesion through collective agricultural work.

The project also offers a symbolic shift: transforming land once associated with pollution and exploitation into a source of renewal and cooperation. When implemented through participatory frameworks — where communities are involved in site selection, monitoring, and benefit-sharing — the intervention can help rebuild trust between citizens, traditional authorities, and local government institutions.

Furthermore, industrial hemp's versatility allows diversification of local economies beyond gold and cocoa. Value-added processing such as fibre production, biochar generation, and seed-oil

⁴ Michael Asante Biney et al., "Ghana's Galamsey Crisis: Understanding the Roots and Ripple Effects of Illegal Mining," June 11, 2025, <https://doi.org/10.21203/rs.3.rs-6869246/v1>

⁵ Natalia Yakovleva, "Perspectives on Female Participation in Artisanal and Small-Scale Mining: A Case Study of Birim North District of Ghana," *Resources Policy* 32, no. 1-2 (March 2007): 29–41: <https://doi.org/10.1016/j.resourpol.2007.03.002>

extraction can create new artisanal and small-enterprise activities, fostering rural entrepreneurship and retaining youth within their home districts.

3.2 Health Impact

The health consequences of artisanal mining are among the most severe environmental-health challenges in Ghana. Mercury, arsenic, lead, and cadmium exposure — common by-products of gold extraction — cause multi-system toxicity, affecting the nervous, renal, reproductive, and cardiovascular systems. Chronic exposure leads to fatigue, respiratory disorders, dermatological lesions, memory loss, infertility, and increased risks of miscarriage and congenital anomalies⁶. Mercury in particular crosses the placental barrier, leading to neurological impairment and developmental delays in children. Water contamination extends these risks to entire communities, even those not directly engaged in mining⁷.

Implementing phytoremediation with industrial hemp can mitigate these long-term exposures in several ways. By extracting and immobilizing heavy metals in the soil, hemp reduces their bioavailability and prevents entry into water and food chains. Over successive cultivation cycles, measurable declines in soil and water contaminant concentrations can yield tangible public-health improvements.

The introduction of safe biomass management protocols — avoiding the use of contaminated plant material in food or household products — also reduces secondary exposure risks. The DECON HEMP initiative can complement Ghana's national health policies by integrating environmental remediation with preventive health strategies, especially maternal and child-health programs in mining-affected districts.

Public-awareness campaigns, delivered through radio and community outreach, can disseminate information on safe water use, soil management, and personal protection from contaminants. Coupled with local health monitoring — such as periodic testing of water, crops, and human biomarkers (hair, urine, blood) — these efforts will allow quantitative tracking of health benefits over time.

The expected outcome is a gradual **reduction of environmentally mediated disease burdens**, decreased reproductive toxicity, and enhanced overall well-being, particularly among vulnerable groups: women of child-bearing age, children, and elderly residents.

3.3 Impact on Fertility and Reproductive Health

Mining-related contamination has well-documented reproductive consequences. Elevated concentrations of mercury, cadmium, and arsenic disrupt endocrine function and impair gametogenesis. Studies among men working in Ghana's ASM areas show reduced sperm count and motility, while women exposed to contaminated water sources experience higher rates of miscarriage, stillbirth, and premature birth⁸.

⁶ Jonathan Awewomom et al., "A Review of Health Hazards Associated with Exposure to Galamsey-Related Pollutants," *Health Sciences Investigations Journal*, no. Volume 5 Issue 2 (June 20, 2024), <https://doi.org/10.46829/hsijournal.2024.6.5.2.726-734>

⁷ Richard B Opoku et al., "Environmental Exposure and Potential Health Impact of Heavy Metals in Previous Mining Communities in Ghana.," *Health Sciences Investigations Journal*, no. Volume 5 Issue 2 (June 20, 2024), <https://doi.org/10.46829/hsijournal.2024.6.5.2.702-709>

⁸ Arhin, S. K., Barnes, P., Arhin, I. K., & Owusu-Nyarko, B. (2025). Effect of 'Galamsey' on human fertility: A systematic review. *Health Science Reports*, 8(3), e70602. <https://doi.org/10.1002/hsr2.70602>

By lowering heavy-metal exposure, industrial hemp-based remediation contributes indirectly to **restoring reproductive health**. Over multiple cropping cycles, as soil and water quality improve, background exposure levels are expected to fall. This process can be reinforced through health-education programs, providing information on nutrition, prenatal care, and occupational safety.

Although environmental recovery is gradual, the project's emphasis on gender inclusion — ensuring women's access to remediated land and participation in cultivation — means that reproductive-health benefits will coincide with broader social empowerment. Cleaner environments will reduce intergenerational transmission of toxic burdens, giving future generations a healthier developmental foundation.

3.4 Economic Impact

Economically, the DECON HEMP approach represents a paradigm shift from **extractive and finite resource use** to **restorative and regenerative production**. Illegal mining, despite generating short-term income, undermines long-term prosperity by destroying farmland, polluting water, and eroding the tax base. The cumulative costs — health care, lost agricultural output, infrastructure damage, and remediation — far exceed any short-term gains.

Phytoremediation with industrial hemp addresses these losses through a **triple-value mechanism**:

1. **Ecological restoration**
of land that is currently unproductive, allowing future agricultural or forestry use. Restored land increases property values and strengthens food security.
2. **Livelihood creation**
by the cultivation and processing of industrial hemp which generate employment for local populations — both men and women — through field management, harvesting, biomass transport, and processing. Each hectare of hemp can sustain multiple seasonal jobs, far surpassing the labour absorption of mechanized mining.
3. **Industrial innovation**
through safe valorization of biomass (biochar, biofuels, industrial fibres, biocomposites) which creates a green-industrial base in rural regions, potentially linked to construction, energy, industrial pre-fabrication and packaging sectors.

From a macroeconomic standpoint, Ghana's emerging industrial-hemp market (estimated growth rate ≈ 2.5 % annually) can provide a legal and tax-compliant revenue stream, complementing agricultural exports. If scaled, industrial hemp remediation could contribute to GDP diversification by introducing a bioeconomy segment tied to climate-action financing and carbon-credit mechanisms. International climate funds and sustainable-investment programs increasingly support land-restoration projects with measurable carbon-sequestration and social-impact metrics — criteria that DECON HEMP meets.

Economic modelling based on comparable phytoremediation pilots suggests that industrial hemp restoration yields cost savings of up to 70 % compared to conventional cleanup while creating long-term land value exceeding initial investment. Beyond financial returns, the project delivers non-market benefits — improved ecosystem services, reduced disaster vulnerability, and enhanced community stability — that are rarely captured in traditional cost-benefit analyses but essential to sustainable development.

3.5 Environmental Co-Benefits

The environmental co-benefits of industrial hemp-based remediation reinforce its economic logic. Industrial hemp's dense canopy and rapid ground coverage limit erosion, while its deep root system improves soil aeration and structure. As metals are immobilized or extracted, microbial communities gradually recover, enabling re-establishment of soil fertility. In the medium term, restored sites can transition to agroforestry or mixed cropping, integrating food or timber species once contaminant thresholds are safely reduced.

Additionally, industrial hemp cultivation sequesters significant quantities of carbon — up to 15 t CO₂ ha⁻¹ yr⁻¹ depending on biomass yield. When contaminated biomass is transformed into biochar, a portion of this carbon becomes permanently stored in the soil, contributing to Ghana's emission-reduction commitments under its Nationally Determined Contributions (NDCs).

By combining pollution mitigation with climate-change adaptation, DECON HEMP exemplifies a nature-based solution that directly advances multiple Sustainable Development Goals: SDG 3 (Good Health), SDG 8 (Decent Work), SDG 9 (Industry & Innovation), SDG 12 (Responsible Consumption), SDG 13 (Climate Action), and SDG 15 (Life on Land), while indirectly supporting SDGs 1, 2, 5, and 17.

3.6 Long-Term Social Transformation

Beyond immediate remediation outcomes, the DECON HEMP model can catalyse long-term **social transformation** in mining regions. By creating a legal, productive alternative to illegal gold extraction, it offers communities a dignified livelihood anchored in stewardship rather than exploitation.

Women's participation in cooperative structures — supported by access to microcredit and training — will strengthen household resilience and contribute to closing the gender income gap. Local youth can gain technical and entrepreneurial skills in agriculture, environmental monitoring, and bio-industrial processing, aligning with Ghana's Green Jobs Strategy.

Institutionally, the project fosters collaboration between local authorities, research institutions, and civil-society organizations, encouraging a governance culture based on transparency and shared responsibility for environmental resources. Over time, these dynamics can help break the dependency on extractive economies, replacing them with a regenerative framework that links ecological integrity, social justice, and economic inclusion.

4. Vulnerability and Needs Assessment

This chapter identifies the groups most affected by environmental degradation from illegal mining and assesses their socio-economic vulnerabilities, livelihood dependencies, and adaptive capacities. The analysis focuses on three population categories — **farmers, women, and children** — whose exposure to pollution and structural disadvantages intersect, creating chronic poverty and health risks. It also discusses the underlying causes of vulnerability, including land tenure insecurity, gender inequality, limited institutional support, and weak enforcement of environmental and labour laws. Understanding these dynamics is essential for designing equitable and sustainable remediation programs under the DECON HEMP initiative.

4.1 Overview of Affected Populations

Illegal and small-scale mining in Ghana has left a complex social legacy.

Entire communities in the Western, Ashanti, Central, and Eastern Regions now live amid degraded landscapes where agricultural productivity has collapsed, water sources are polluted, and traditional income systems have been disrupted. The livelihoods of local households, once rooted in cocoa, cassava, yam, and plantain cultivation, have been displaced by a speculative gold economy that benefits a few and impoverishes many.

The consequences of this transformation are unevenly distributed. Men dominate the visible mining workforce, but **women and children bear disproportionate burdens** of economic insecurity, unpaid care work, and exposure to contaminated environments. Farmers whose lands have been excavated or silted by runoff often have no financial cushion or access to compensation, pushing families into debt or migration. Environmental degradation therefore functions as both a cause and a multiplier of vulnerability: it erodes natural capital while deepening social inequality.

4.2 Farmers: Loss of Livelihoods and Ecological Dependence

For smallholder farmers, land is both the primary asset and the foundation of cultural identity.

When illegal mining converts fertile plots into toxic pits, the loss is existential. A 2023 survey by Ghana's Environmental Protection Agency found that over **190,000 acres of farmland** (about 77,000 hectares) in major cocoa-producing zones have been rendered unfit for cultivation due to heavy-metal contamination or physical destruction.

Farmers in these areas face a combination of shocks: declining yields, rising costs of inputs, and the absence of viable alternatives. Many have turned to short-term wage labour in mining or charcoal burning, further accelerating ecological decline. Their vulnerability is compounded by limited access to credit and extension services — only about one-third of farmers receive technical support or can afford fertilizers, and less than one-fifth have formal contracts guaranteeing prices or land use.

DECON HEMP directly addresses this livelihood crisis by restoring degraded farmland and offering an alternative income source that is both environmentally regenerative and economically viable. Involving farmers in remediation — from soil sampling to hemp cultivation — builds ownership and technical capacity. Once land is restored, farmers can transition back to food crops or integrate industrial hemp into rotational systems for fibre or biochar production. This approach transforms remediation from an external intervention into a **participatory process of rural reconstruction**.

4.3 Women: Structural Inequality and Opportunity Gaps

Women in Ghana's rural economy perform more than half of all agricultural and household labour, yet their access to productive assets remains severely restricted.

Customary land tenure systems, which predominate in most mining-affected regions, assign land ownership primarily to men. As a result, women cultivate smaller plots, often on marginal soils, and depend on male relatives or chiefs for access.

The spread of galamsey has worsened these inequalities. When land is seized or polluted, women — especially widows and female-headed households — are the first to lose their means of subsistence. Without land titles or savings, they are also excluded from formal credit systems. Consequently, many engage in unregulated trade or petty mining activities that expose them to mercury vapours and physical hazards.

Environmental contamination further undermines women's health. Reproductive disorders linked to heavy-metal exposure — miscarriage, stillbirth, premature birth — are frequent in mining communities. Water scarcity caused by river pollution increases their workload, as they must travel longer distances to fetch clean water for household use.

By incorporating women into all phases of DECON HEMP — from nursery work and planting to fibre processing and local marketing — the project aims to **convert vulnerability into agency**. Land-allocation schemes within restored sites can reserve portions for women's cooperatives, ensuring secure access and income. Training programs should combine agronomic instruction with financial literacy and cooperative management skills, empowering women not only as workers but as stakeholders. This inclusion aligns with Ghana's National Gender Policy (2015) and the UN Sustainable Development Goal 5 on gender equality.

4.4 Children: Exposure, Labour, and Lost Futures

Children constitute one of the most affected and least protected groups in mining regions.

Estimates from the Ghana Statistical Service and the ILO indicate that **more than 770,000 children** are engaged in cocoa farming, mining, or associated support work, with up to 20 % performing hazardous tasks such as carrying heavy loads, handling mercury amalgam, or operating crushing machinery.

The consequences are long-term and multidimensional. Physical injuries, respiratory illnesses, and neurological impairments reduce life expectancy and cognitive development. School attendance declines as families prioritize short-term survival over education, perpetuating intergenerational poverty. Even children not directly employed in mining are exposed through contaminated soil, air, and water. Mercury and lead bioaccumulate in local fish and crops, affecting nutrition and brain development.

DECON HEMP's educational and employment strategy can serve as a **preventive child-protection mechanism**. By creating stable jobs for adults and promoting community engagement, it reduces economic pressure on families to rely on child labour. Environmental-education campaigns, conducted through schools, local radio and NGOs like Recycle-Up Ghana, can raise awareness among parents and youth about the risks of pollution and the benefits of land restoration. Partnerships with the Ghana Education Service and local NGOs could integrate school-garden programs using industrial hemp or non-food cover crops, linking remediation with

learning and nutrition. Over time, this approach strengthens the human-capital base that sustainable land management requires.

4.5 Causes of Vulnerability

The vulnerabilities described above arise from a convergence of structural and proximate factors:

1. **Chronic poverty and inequality**
Rural households have few buffers against shocks. Degraded land reduces yields and income, forcing reliance on informal mining or seasonal migration.
2. **Gender-based exclusion**
Patriarchal land tenure and cultural norms limit women's control over assets and decision-making.
3. **Weak institutional capacity**
Enforcement of environmental, labour, and child-protection laws is inconsistent; local authorities often lack resources or political backing to regulate galamsey.
4. **Limited access to services**
Agricultural extension, education, and healthcare are underfunded in remote areas, constraining adaptation.
5. **Environmental decline**
Deforestation, water pollution, and soil toxicity undermine resilience, leading to cascading socio-economic impacts.

Addressing these drivers requires integrated action that combines ecological restoration with social protection and governance reform.

4.6 Needs Assessment and Response Priorities

Based on consultations and existing studies, four principal needs emerge for vulnerable groups in mining zones:

1. **Livelihood diversification**
Secure and sustainable alternatives to illegal mining, such as hemp cultivation, agroforestry, and eco-tourism.
2. **Access to land and credit**
Legal mechanisms for women and smallholders to obtain rights to restored plots and microfinance for start-up inputs.
3. **Health and education services**
Community clinics, safe-water programs, and school retention initiatives to mitigate the legacy of contamination.
4. **Capacity building and governance**
Training for local leaders, cooperatives, and NGOs in environmental management, monitoring, and participatory planning.

DECON HEMP responds directly to these needs. By coupling technical remediation with livelihood programs and social inclusion, it can become a **model of integrated territorial recovery**.

Participatory governance mechanisms — local steering committees including women's and youth representatives — should oversee implementation, ensuring transparency and equitable benefit distribution. Partnerships with regional universities, such as the University of Ghana, the Bolgatanga Technical University, and especially the Kumasi based Kwame Nkrumah University of

Science & Technology can provide scientific and vocational training, linking education with practical restoration outcomes.

4.7 Outlook: From Vulnerability to Resilience

The **transformation of vulnerability into resilience** hinges on empowerment, participation, and environmental justice. Restoring contaminated land is not only a technical challenge but a social contract that redefines who has the right to use and benefit from natural resources.

If designed inclusively, DECON HEMP can demonstrate that ecological recovery and social equity are mutually reinforcing: remediated land returns dignity to dispossessed farmers, inclusion of women in production systems promotes fairness and efficiency, and protecting children's education secures the region's (and the nation's) long-term development.

By addressing the root causes of vulnerability — poverty, exclusion, and environmental neglect — the project contributes to building self-reliant, adaptive communities capable of sustaining Ghana's transition toward a green and inclusive economy.

5. Women in Ghana and Inclusion Strategy

This chapter analyses the socio-economic position of women in Ghana, emphasizing how structural inequality, limited asset ownership, and environmental degradation intersect to perpetuate vulnerability — particularly in mining-affected areas. It outlines the rationale for gender inclusion in the DECON HEMP program and proposes a multi-level strategy for empowering women as **agents of change** in ecological restoration, entrepreneurship, and community governance. The approach aligns with national and international commitments to gender equality and inclusive green-economy transformation.

Women's empowerment is central to the sustainability of DECON HEMP. By integrating women into all dimensions of the project — economic, technical, and political — the initiative contributes not only to environmental remediation but also to **social renewal** and democratic inclusion.

As custodians of households, markets, and community welfare, women embody the continuity between ecological health and social well-being. Their active leadership transforms the restoration of polluted land into a broader project of cultural and institutional regeneration.

5.1 The Socio-Economic Context of Women in Ghana

Women play a pivotal role in Ghana's economy, especially in agriculture, trade, and informal services. They constitute **nearly 52 % of the population** and provide over **half of all agricultural labour**, yet their participation is concentrated in low-income and vulnerable employment. According to the Ghana Statistical Service, approximately 79 % of women work in informal or self-employed positions compared to 57 % of men, with minimal social protection and limited access to credit, land, or modern technology.

Despite significant progress in education and health outcomes over the past two decades, economic inequality persists. The proportion of women in Parliament remains around 15 %, and only one-quarter hold senior or managerial positions nationally. Cultural norms, patriarchal inheritance systems, and gendered divisions of labour continue to shape opportunities.

In rural communities, especially those impacted by illegal mining, the situation is exacerbated by land dispossession, pollution, and declining agricultural productivity. When soil and water become unsafe, women lose both income and autonomy, as they rely heavily on subsistence farming, food processing, and petty trading tied to local ecosystems.

Ghana's National Gender Policy (2015) identifies three interrelated barriers to women's empowerment:

1. **Unequal access to productive resources**
including land and capital;
2. **Gender-based violence and social norms**
restricting mobility and decision-making; and
3. **Weak institutional enforcement**
of gender equality commitments.

DECON HEMP directly contributes to overcoming these barriers by designing restoration activities that integrate women as workers, entrepreneurs, and leaders in the green economy.

5.2 Women and Environmental Degradation

Environmental degradation disproportionately affects women because their livelihoods and daily responsibilities depend on natural resources. When rivers are polluted or forests cleared, women must travel longer distances to collect water or fuelwood, increasing physical strain and exposure to insecurity.

In mining zones, mercury contamination adds an invisible health risk. Women engaged in ore washing or in processing tailings are frequently exposed to toxic vapours without protection. Even those not directly involved suffer secondary exposure through contaminated fish, soil, or drinking water.

Health effects include anemia, respiratory infections, miscarriages, and developmental disorders in children. The social costs — time lost to illness, caregiving burdens, and declining agricultural productivity — create a cycle of impoverishment that is both gendered and intergenerational.

By linking soil remediation with women's employment, DECON HEMP offers a means to restore both environmental and social health. Women are not passive victims but potential **stewards of ecological recovery**; their participation ensures that remediation reflects community priorities such as water quality, food security, and family well-being.

5.3 The Business Case for Gender Inclusion

Beyond ethical and legal imperatives, gender inclusion improves project efficiency and sustainability. Research consistently shows that initiatives with strong female participation achieve better environmental and economic outcomes. Women often demonstrate higher repayment rates in credit programs, greater attention to resource stewardship, and strong community accountability.

For DECON HEMP, gender inclusion yields several tangible advantages:

- **Enhanced productivity**
Mixed-gender teams combine technical and local knowledge, improving field management and problem-solving.
- **Social legitimacy**
Projects perceived as inclusive gain stronger community acceptance, reducing conflict and stigma associated with hemp cultivation.
- **Market diversification**
Women entrepreneurs can drive value-added product development — cosmetics, textiles, construction materials — broadening income streams.
- **Knowledge transfer**
Training women fosters intergenerational learning, as women are primary educators in households.

Thus, inclusion is not a symbolic gesture but a core efficiency driver and risk-management strategy for DECON HEMP.

5.4 The Inclusion Strategy

The inclusion strategy adopts a **three-tiered approach**:

1. Participation in Remediation and Cultivation

- Women will be prioritized for employment in seedling production, nursery management, soil testing assistance, planting, and harvesting. These activities align with existing skill sets from agriculture and processing while providing formal income and training.
- Where feasible, portions of remediated land will be allocated to women's cooperatives under transparent tenure agreements supported by local authorities and traditional councils. This ensures that restored ecosystems translate directly into economic opportunity for those most affected by degradation.

2. Empowerment through Enterprise and Capacity Building

The second tier focuses on developing women's roles in the industrial hemp value chain beyond primary cultivation. Training modules will cover:

- agronomic best practices and environmental monitoring,
- safe biomass handling and transformation into biochar or fibre,
- business development, cooperative management, and financial literacy.

Microfinance partnerships and revolving funds can facilitate access to small loans for processing equipment, such as decorticators or briquette presses. These investments transform women from wage labourers into entrepreneurs, reinforcing long-term autonomy.

3. Leadership and Decision-Making

Sustainable inclusion requires that women hold decision-making power within project structures.

- Each DECON HEMP local steering committee will reserve at least 50 % representation for women, ensuring meaningful input in land-allocation, benefit-sharing, and monitoring decisions.
- Mentorship programs linking female farmers, scientists, and policymakers can strengthen leadership pipelines.

By making women visible in technical and governance roles, the project challenges traditional gender hierarchies and redefines environmental management as a shared civic responsibility.

5.5 Safeguards and Enabling Conditions

For inclusion to succeed, institutional safeguards must be embedded in project design:

- 1. Gender-Sensitive Policies**
All training materials, contracts, and monitoring tools will use gender-inclusive language and ensure equitable access.
- 2. Occupational Health and Safety**
Protective equipment and health insurance will be provided for field workers, recognizing women's physiological and reproductive health needs.
- 3. Land-Tenure Support**
Collaboration with local land commissions and chiefs to secure written agreements granting women's groups usufruct rights to restored plots.
- 4. Monitoring and Evaluation**
Gender-disaggregated indicators will track employment, income, leadership participation, and social impact.

5. Prevention of Gender-Based Violence

Clear grievance mechanisms and awareness campaigns will promote respectful workplaces and community relations.

These measures transform inclusion from aspiration into enforceable practice, guaranteeing that benefits reach intended participants.

5.6 Expected Outcomes

The implementation of this inclusion strategy is expected to yield multiple outcomes:

- **Economic Empowerment**
Increased income and financial autonomy for women in mining-affected districts.
- **Health Improvement**
Reduced exposure to pollutants through safer working environments.
- **Social Cohesion**
Strengthened community networks as women's groups coordinate local restoration initiatives.
- **Policy Influence**
Enhanced visibility of women's leadership in environmental governance, contributing to national policy dialogues on sustainable land management.

In the long term, these outcomes will contribute to structural change in gender relations, embedding equality as a principle of Ghana's green-transition agenda.

5.7 Strategic Partnerships

The success of the inclusion strategy depends on collaboration among diverse partners:

- **Government**
Ministry of Gender, Children and Social Protection;
Ministry of Food and Agriculture;
Environmental Protection Agency.
- **Academic Institutions**
Kwame Nkrumah University of Science and Technology,
University of Ghana, and
regional polytechnics for research and training.
- **Civil Society**
Women in Agriculture Development (WIAD),
the Ghana Federation of Women Entrepreneurs, and
local NGOs specializing in gender justice.
- **International Organizations**
UN Women,
FAO, and
EU/AU for technical and funding support.

These alliances ensure coherence between project implementation and broader national strategies, scaling local successes into systemic transformation.

6. Community Engagement and Adaption

This chapter outlines the social strategy for engaging and mobilizing communities in DECON HEMP. It examines how perceptions of industrial hemp, shaped by historical, cultural, and legal associations, may influence public acceptance, and describes communication, education, and participatory mechanisms designed to build trust and shared ownership. It also discusses the role of local institutions, traditional authorities, and youth organizations in facilitating behavioural adaptation, ensuring that remediation is understood not only as a technical intervention but as a collective transformation toward environmental stewardship.

6.1 The Importance of Community Participation

Experience from land-restoration programs worldwide demonstrates that technical success depends largely on **social legitimacy**. In Ghana, where historical mistrust of top-down projects persists, meaningful community participation is indispensable.

Mining-affected communities are not passive beneficiaries but key actors whose knowledge, cooperation, and initiative determine sustainability. Many residents have lived for decades amid pollution and broken promises of rehabilitation. Without transparent engagement, even well-intentioned interventions can be met with scepticism or resistance.

Community engagement therefore forms the social backbone of DECON HEMP. The approach aims to rebuild confidence in environmental governance by ensuring that local voices shape every phase — from site selection and planting to monitoring and benefit-sharing. Participation is also a means of adaptation: as people learn the ecological and economic value of remediation, they shift from dependence on extractive activities to ownership of restorative practices.

Involving communities early encourages a sense of pride and belonging; remediated sites become shared assets rather than external projects. This participatory foundation is critical for preventing land conflicts, clarifying expectations, and embedding gender and youth inclusion at every level.

6.2 Perceptions of Industrial Hemp in Ghana

One of the primary communication challenges concerns **public perception of hemp**. Although industrial hemp varieties contain negligible amounts of psychoactive compounds (THC < 0.3 %), many Ghanaians still associate the plant with illegal cannabis cultivation and narcotic use. These perceptions stem from historical prohibitions, limited public education, and conflation between industrial and recreational strains.

To achieve broad acceptance, DECON HEMP must differentiate industrial hemp from cannabis for consumption use, emphasizing its industrial, environmental, and socio-economic applications. Clear messaging should highlight:

- Industrial hemp's global recognition as a legal crop under controlled licensing frameworks,
- its uses in textiles, construction, bioplastics, and phytoremediation, and
- Ghana's emerging policy reforms that permit industrial hemp production under strict regulation.

Communication must also acknowledge community concerns rather than dismiss them. Dialogue about legality, safety, and moral implications should be framed in local cultural and religious terms, appealing to values of stewardship, productivity, and collective well-being.

Through consistent and transparent communication, the project can transform initial scepticism into **pride that Ghana is pioneering a green innovation** aligned with its environmental and economic goals.

6.3 Communication Strategy

The communication strategy for DECON HEMP integrates education, dialogue, and visibility. Its objectives are to

**inform,
involve,
inspire**

stakeholders at multiple levels — from national policymakers to farmers, teachers, traditional and religious leaders.

Information and Awareness

Educational campaigns will explain the science and legality of industrial hemp, focusing on its safety and benefits for land restoration. Communication channels include:

- community radio programs in local languages,
- short documentaries and testimonials from pilot farmers,
- school-based environmental clubs, and
- open field days where residents can observe progress.

Dialogue and Participation

Regular town-hall meetings and stakeholder forums will allow residents to express concerns, ask questions, and propose solutions. Local languages and inclusive facilitation methods will ensure accessibility for women, elders, and youth.

Visibility and Transparency

Public display boards at project sites will summarize key data — soil testing results, environmental indicators, employment statistics — reinforcing transparency. By demystifying both the plant and the process, the project cultivates **trust and accountability**, vital for long-term cooperation.

6.4 The Role of Traditional Authorities and Local Institutions

Traditional authority in Ghana is not merely ceremonial — it is a living institution that governs land allocation, conflict resolution, and moral order. Chiefs, queen mothers, and community elders maintain deep legitimacy among rural populations and often exercise more influence than formal state structures.

Among these institutions, **the Asantehene, King of the Ashanti Kingdom**, holds a uniquely powerful and respected position. As spiritual and cultural leader of the Ashanti people, His Majesty commands not only regional authority but national recognition as a symbol of unity, justice, and continuity. His advocacy for environmental restoration, cultural heritage, and youth development has made the Ashanti Kingdom a beacon of traditional leadership in sustainable governance.

For DECON HEMP, partnership with the Asantehene and the Asanteman Council is strategically vital. The Ashanti Region is one of the most affected by illegal mining, yet it also possesses strong local governance structures and a **tradition of collective labour** (*nnoboa*) that aligns with the project's participatory approach. By engaging the Asantehene as a **patron and champion** of ecological restoration, the project can benefit from unparalleled credibility, mobilization power, and continuity. His endorsement can legitimize industrial hemp as a socially acceptable and morally aligned innovation for healing the land — a transformation consistent with his broader environmental advocacy, including tree planting, river protection, and cultural conservation initiatives.

Practically, the Asantehene's involvement can include:

- Convening regional dialogues among traditional rulers to coordinate land restoration across districts;
- Mediating land-access agreements between local chiefs, government agencies, and project implementers;
- Supporting community education campaigns through the Otumfuo Foundation, emphasizing environmental stewardship, youth employment, and responsible resource management;
- Encouraging traditional councils to dedicate degraded communal lands to pilot remediation projects.

Beyond the Ashanti Kingdom, the engagement of other paramount chiefs, queen mothers, and traditional councils across Western, Central, and Eastern Regions will ensure inclusive representation of Ghana's diverse cultural heritage. Queen mothers, in particular, serve as custodians of family welfare and can mobilize women's associations for nursery work, cooperative farming, and awareness campaigns. Their involvement ensures that remediation resonates with community values of harmony (*nkabom*), balance (*ahoto*), and respect for the earth.

Local government bodies — such as district assemblies, environmental subcommittees, and community development offices — will complement these traditional structures, providing regulatory oversight, data collection, and linkage to national ministries.

Religious institutions, schools, and local NGOs will reinforce shared responsibility by framing environmental restoration as both a moral duty and a civic right.

By anchoring DECON HEMP within the leadership of the Asantehene and the wider network of traditional authorities, the project gains not only legitimacy but cultural depth. Restoration becomes an act of **heritage renewal** — a collective commitment to protect the land entrusted by ancestors and preserve it for future generations.

6.5 Youth Engagement and Knowledge Transfer

Young people are central to behavioural adaptation. Many rural youths participate in illegal mining because it offers quick cash and a sense of independence, even as it destroys their future prospects. DECON HEMP provides an alternative vision — employment that combines income with environmental purpose.

Training modules targeting youth will cover modern farming, soil science, and green entrepreneurship. Apprenticeship programs with technical universities can prepare them for

careers in renewable materials, environmental monitoring, and circular-economy enterprises. By linking ecological restoration to personal empowerment, the project positions youth as **agents of change** rather than marginal participants.

Knowledge transfer must also be intergenerational. Elders possess traditional ecological knowledge — seasonal patterns, soil fertility indicators, water management — that complements scientific approaches. Integrating these knowledge systems fosters respect and cultural continuity while promoting innovation rooted in local experience.

6.6 Community Adaptation to Environmental Change

Community adaptation extends beyond acceptance of industrial hemp; it involves **rethinking the relationship between people and land**. Climate variability, soil degradation, and water scarcity have forced communities to adopt coping strategies that are often maladaptive — illegal mining, overharvesting of forests, or shifting cultivation. DECON HEMP introduces a positive adaptation pathway: transforming degraded environments into productive assets through collective action.

Adaptation will be supported through:

- participatory mapping of degraded sites and resources,
- training in sustainable land management and water conservation,
- integration of indigenous practices such as intercropping and mulching, and
- community-managed monitoring systems for soil and water quality.

Such activities foster ecological literacy and practical skills, enabling residents to anticipate environmental risks and respond proactively. Over time, this knowledge base will reinforce Ghana's broader climate-adaptation agenda by building resilience from the ground up.

6.7 Feedback and Grievance Mechanisms

Effective engagement requires clear mechanisms for feedback and accountability. DECON HEMP will establish **multi-channel grievance systems**, allowing community members to report concerns, suggest improvements, or lodge complaints.

These include:

- designated contact persons in each community committee,
- confidential suggestion boxes at project sites,
- a toll-free phone line, and
- periodic evaluation forums where results and challenges are discussed openly.

All grievances will be addressed through transparent procedures with written responses and follow-up. Special attention will be given to gender-sensitive mechanisms, ensuring that women feel safe reporting issues such as harassment or exclusion.

A responsive feedback system reinforces trust, ensures social safeguards, and improves project design through continuous learning.

6.8 Monitoring Social Acceptance and Behavioural Change

To evaluate community adaptation, social indicators will complement environmental monitoring. Key parameters include:

- community participation rates (disaggregated by gender and age),
- changes in attitudes toward hemp cultivation (measured through surveys and focus groups),
- incidence of land-use conflicts, and
- local contributions to project maintenance and expansion.

Periodic qualitative assessments — stories of change, interviews, participatory videos — will capture intangible benefits such as pride, ownership, and collective identity. By documenting shifts in perception and behaviour, DECON HEMP can demonstrate that remediation is not only cleaning the soil but renewing social relationships with nature.

6.9 Expected Outcomes

- **Improved public understanding**
of industrial hemp as a legitimate environmental tool;
- **Strengthened trust**
between communities, government, and project implementers;
- **Active participation**
of traditional leaders, women, and youth in restoration activities;
- **Behavioural change**
from extractive to regenerative land-use practices;
- **Institutionalized dialogue**
and grievance mechanisms for long-term governance.

These outcomes ensure that community engagement evolves from information sharing to co-management, anchoring DECON HEMP within Ghana's cultural and social fabric.

6.10 Strategic Partnerships

The success of DECON HEMP's community engagement and adaptation plan depends on strong, sustained partnerships that connect local participation with institutional capacity and national policy support.

While traditional authorities and local assemblies anchor legitimacy at the grassroots level, broader collaboration among public agencies, academic institutions, civil-society organizations, and international partners ensures technical quality, regulatory compliance, and long-term scalability.

- **National and Regional Institutions**
The Environmental Protection Agency (EPA),
the Ministry of Environment, Science, Technology and Innovation (MESTI),
the Ministry of Food and Agriculture (MoFA)

are central partners for environmental oversight, research, and agricultural extension. Their collaboration will ensure that pilot projects meet national environmental standards and integrate smoothly with the National Climate Change Policy (NCCP) and the Nationally Determined Contributions (NDCs).

Regional Coordinating Councils and District Assemblies will provide administrative support, facilitating alignment between local action plans and national development frameworks.

- **Traditional Leadership and Cultural Institutions**

Under the guidance of the Asantehene and the Asanteman Council, DECON HEMP will strengthen relationships with paramount chiefs and queen mothers across affected regions. These leaders will coordinate community participation, allocate communal land for pilots, and host public education events. Their continued involvement guarantees cultural legitimacy and helps embed environmental stewardship within Ghana's moral and spiritual traditions.

- **Academic and Research Partners**

Partnerships with universities such as

the University of Ghana.

the Kwame Nkrumah University of Science and Technology (KNUST), and

the University for Development Studies (UDS)

will support technical research, data collection, and training. Their environmental-science and agricultural-engineering departments can supervise soil-monitoring programs, develop local industrial hemp cultivars, and design biochar filtration prototypes suited to Ghanaian conditions.

- **Civil Society and NGOs**

Local and international NGOs such as

A Rocha Ghana,

Friends of the Nation,

Youth Bridge Foundation,

Recycle-Up Ghana and

Women in Agriculture Development (WIAD)

will play vital roles in social mobilization, gender inclusion, and capacity building. Their networks extend deep into rural communities, facilitating outreach to women's cooperatives, youth groups, and schools.

- **Private Sector and Social Enterprises**

Engagement with private investors and green start-ups will stimulate innovation in bio-industrial processing, renewable materials, and impact financing. Partnerships with sustainable-finance institutions and microcredit providers can support women's and youth cooperatives with working capital and equipment loans.

- **International and Development Partners**

Organizations such as

UNDP,

UN Women,

FAO, EU/AU, and the

World Bank

offer technical expertise and potential co-financing for integrated restoration programs.

Collaboration with regional initiatives — for example, ECOWAS’s environmental-governance platforms — can help scale successful pilot models to neighbouring countries.

Together, these partnerships create a **multi-layered governance ecosystem** linking community empowerment with national and global sustainability agendas. They transform DECON HEMP from a local remediation project into a model of participatory, multi-stakeholder environmental governance—where science, culture, and policy converge to heal both people and land.

7. Legal and Policy Feasibility

This chapter examines Ghana's legal and institutional framework relevant to industrial hemp cultivation, environmental remediation, and sustainable land management. It assesses how existing laws, policies, and international commitments enable—or constrain—the implementation of the DECON HEMP initiative. The analysis highlights the emerging regulatory space for industrial hemp following the Narcotics Control Commission Act of 2020 (Act 1019), reviews environmental and agricultural policies that govern land use, and outlines pathways for coordination among government agencies, traditional authorities, and private actors. The chapter concludes with recommendations for harmonizing regulations, securing legal clarity, and aligning DECON HEMP with Ghana's national development and climate objectives.

7.1 The Legal Status of Industrial Hemp in Ghana

Until recently, all cannabis-related cultivation in Ghana was strictly prohibited under the Narcotics Control Commission Act, 1990 (PNDCL 236). However, the legal environment has evolved substantially. The Narcotics Control Commission Act, 2020 (Act 1019) introduced a regulated framework permitting the cultivation of cannabis with tetrahydrocannabinol (THC) content not exceeding 0.3% for industrial and medicinal purposes. This legislative shift reflects Ghana's recognition of the plant's economic and environmental potential within controlled systems.

Under Act 1019, the Narcotics Control Commission (NACOC) is responsible for issuing licenses for industrial hemp production, in consultation with the Ministry of Interior and the Ministry of Health. While the Act does not explicitly mention phytoremediation, it provides a legal entry point for research-based cultivation, particularly when coordinated with environmental agencies and universities. In practice, pilot programs such as DECON HEMP would operate under research or environmental rehabilitation licenses, pending detailed subsidiary legislation on industrial hemp production and processing.

However, the regulatory environment remains fragmented. Clear rules on seed importation, THC testing, and biomass handling are still under development. The project must therefore operate within a controlled research framework, with strong documentation and transparent communication to national authorities. Early engagement with NACOC, MESTI, and MoFA is critical to establish precedents for environmentally oriented hemp cultivation.

7.2 Environmental Legislation and Land-Use Governance

Beyond narcotics regulation, DECON HEMP falls under Ghana's broader environmental governance framework. Key instruments include:

- **Environmental Protection Agency Act, 1994 (Act 490)**
Establishes the EPA's mandate to protect and improve the environment, including control of pollutants and management of hazardous waste.
- **Environmental Assessment Regulations (LI 1652)**
Require Environmental Impact Assessments (EIAs) for projects likely to affect the environment. Hemp-based remediation pilots must therefore be screened under EPA procedures, ensuring environmental safeguards and public consultation.
- **Lands Commission Act, 2008 (Act 767)**
Governs land administration and ensures equitable allocation for development.

Coordination with local land commissions will be essential to secure rights to degraded sites targeted for restoration.

- **Water Resources Commission Act, 1996 (Act 522)**

Regulates water use, relevant for irrigation and remediation of aquatic ecosystems.

These frameworks collectively support the project's objectives but require institutional harmonization. Many mining-affected lands fall under customary ownership or overlapping jurisdiction between traditional authorities and state agencies. A memorandum of understanding (MoU) among EPA, NACOC, the Lands Commission, and participating traditional councils would streamline licensing and avoid bureaucratic delays.

7.3 Agricultural and Industrial Policy Environment

Industrial hemp aligns with Ghana's Planting for Export and Rural Development (PERD) initiative, which seeks to diversify agricultural exports beyond cocoa through high-value crops such as cashew, coconut, and shea. Industrial hemp can complement this agenda as a **dual-purpose crop** — restorative and commercial. Moreover, hemp supports the National Industrial Policy (2011) and the One District, One Factory (1D1F) program, offering raw material for bioproduct manufacturing and rural processing enterprises.

However, existing agricultural policies do not yet categorize industrial hemp as an approved industrial crop. DECON HEMP can serve as a **pilot case** to inform policy revision, demonstrating hemp's compliance with food safety, environmental, and trade standards. The Ministry of Food and Agriculture and the Ghana Standards Authority will need to develop guidelines for industrial hemp agronomy, certification, and product quality control.

In this sense, the project is not only a remediation initiative but also a **policy laboratory** — testing governance models, agronomic protocols, and market frameworks for a future regulated hemp industry.

7.4 International Commitments and Legal Compatibility

Ghana's participation in international agreements provides additional legitimacy for industrial hemp-based remediation and circular bioeconomy initiatives. Relevant frameworks include:

- **United Nations Framework Convention on Climate Change (UNFCCC) and Paris Agreement**

Recognize nature-based solutions and sustainable land management as key pathways for emission reduction and adaptation.

- **Convention on Biological Diversity (CBD)**

Supports ecosystem restoration and biodiversity recovery in degraded landscapes.

- **Basel and Minamata Conventions**

Commit Ghana to controlling hazardous waste and reducing mercury emissions—both directly addressed by DECON HEMP through mercury stabilization and biomass management.

- **ECOWAS Environmental Policy (2020–2030)**

Encourages member states to adopt green recovery and pollution control measures using local resources.

By integrating phytoremediation into Ghana's climate and biodiversity strategies, DECON HEMP can access international funding windows under mechanisms such as the Global Environment

Facility (GEF) and the Green Climate Fund (GCF).

7.5 Institutional Roles and Coordination

Effective implementation requires a **multi-agency governance model**. Each stakeholder contributes distinct expertise and authority:

- **NACOC**
Licensing and regulatory oversight for industrial hemp cultivation under Act 1019.
- **EPA**
Environmental assessment, monitoring, and technical supervision of remediation activities.
- **MoFA**
Agricultural extension services, cultivar selection, and integration with rural development programs.
- **MESTI**
Scientific research coordination and innovation promotion.
- **Ministry of Lands and Natural Resources (MLNR)**
Land rehabilitation in mining areas and coordination with Minerals Commission.
- **Traditional Authorities**
Land allocation, cultural legitimacy, and community mobilization (led by the Asantehene and regional councils).
- **Local Government (District Assemblies)**
Project facilitation, social oversight, and inclusion mechanisms.

To ensure coherence, a

National Steering Committee for Phytoremediation and Industrial Hemp

could be established under MESTI, integrating representatives from each institution, traditional leadership, academia, and civil society. This committee would oversee pilot implementation, data sharing, and the formulation of a future National Phytoremediation Policy — a pioneering framework positioning Ghana as a leader in Africa’s green remediation sector.

7.6 Regulatory Gaps and Risks

Despite supportive elements, several gaps must be addressed:

1. **Absence of hemp-specific guidelines**
for phytoremediation — current regulations focus on cultivation for fibre or medicinal uses.
2. **Ambiguity in biomass handling**
Clear rules are needed for processing, transport, and disposal of contaminated plant material.
3. **Overlap of mandates**
among ministries and agencies, which can cause delays or inconsistent interpretations.
4. **Limited institutional capacity**
Most local officials lack expertise in phytotechnology or hemp agronomy.

5. **Public perception and stigma**

Without sustained education, communities may still equate hemp with illicit drugs, affecting adoption.

These risks underline the importance of policy dialogue, institutional training, and transparent communication between DECON HEMP and relevant authorities.

7.7 Policy Opportunities and Pathways Forward

Despite regulatory challenges, DECON HEMP offers multiple policy opportunities:

- **Demonstration Effect**
Successful pilot implementation will provide evidence for integrating phytoremediation into Ghana's environmental policy toolkit.
- **Regulatory Innovation**
Development of THC-testing, licensing, and monitoring protocols tailored to environmental applications.
- **Economic Diversification**
Positioning industrial hemp within Ghana's green-economy and export strategies.
- **Public-Private Partnerships**
Incentivizing impact investors and social enterprises to finance restoration aligned with ESG standards.
- **Knowledge Generation**
Building a scientific evidence base for Africa-wide application, potentially influencing ECOWAS guidelines on soil remediation.

The initiative could culminate in the creation of a

National Framework for Sustainable Industrial Hemp Utilization,

merging environmental restoration with circular bioeconomy principles and social inclusion.

7.8 Strategic Partnerships for Policy Alignment

To achieve regulatory success, DECON HEMP must work through **multi-level partnerships**:

- **Government Ministries**
MoFA, MESTI, MLNR, and the Ministry of Gender, Children and Social Protection to ensure cross-sector coordination.
- **NACOC and EPA**
Primary regulators and guarantors of compliance and environmental safety.
- **Traditional Institutions**
Led by the Asantehene, for legitimacy and cultural integration.
- **Universities and Research Centers:**
To develop scientific protocols and training modules for industrial hemp phytoremediation.
- **Development Partners**
UNDP, UNODC, EU/AU, and the World Bank to provide technical assistance and policy dialogue platforms.
- **Private Sector**
Industrial investors and certification bodies to support commercialization of safe, value-added hemp products.

These partnerships ensure that DECON HEMP operates not as an isolated project but as a **policy innovation hub**, bridging environmental law, economic development, and social transformation.

Ghana's evolving legal framework provides a promising foundation for industrial hemp as a legitimate, regulated crop with environmental and socio-economic potential. Although gaps persist in operational guidelines and inter-agency coordination, the principles of Act 1019, coupled with Ghana's climate and biodiversity commitments, create a conducive environment for pilot implementation. By demonstrating compliance, transparency, and measurable environmental benefits, DECON HEMP can serve as a **precedent-setting model** for integrating phytoremediation into national legislation and regional policy. Ultimately, the initiative's success will depend not only on technical execution but also on its ability to inspire policy coherence—transforming Ghana into a regional leader in sustainable remediation and bio-based innovation.

8. Implementation Plan

This chapter translates the DECON HEMP concept into an operational plan for phased implementation, governance, and monitoring. It defines project objectives, implementation phases, institutional responsibilities, resource requirements, and expected outputs. The approach is participatory and adaptive—designed to integrate scientific research, community engagement, and policy alignment. The plan envisions a **three-phase pilot program** that evolves from research and capacity building to full-scale field application and replication across Ghana's mining-affected regions.

8.1 Implementation Approach

The implementation of DECON HEMP follows a phased, multi-stakeholder model grounded in three principles:

1. **Scientific credibility**

All actions are based on validated research, environmental monitoring, and controlled testing.

2. **Community ownership**

Local people, traditional leaders, and women's cooperatives are direct partners rather than passive beneficiaries.

3. **Institutional integration**

National agencies, traditional authorities, and international partners collaborate under a unified governance structure.

The plan combines field experimentation with socio-economic inclusion, ensuring that remediation creates tangible local benefits — employment, skills development, and restored livelihoods — while generating scientific evidence for policy reform.

8.2 Overall Objective

To demonstrate the technical, social, and economic feasibility of using industrial hemp (*Cannabis sativa L.*) and biochar for remediation of heavy-metal-contaminated soils in Ghana's artisanal mining regions, while building local capacity and regulatory frameworks for large-scale adoption.

Specific objectives:

- Test and optimize h<industrial emp-based phytoremediation techniques under Ghanaian soil and climate conditions.
- Develop biochar filtration and stabilization systems for waterlogged or non-plantable areas.
- Strengthen community and institutional capacity for participatory environmental management.
- Generate policy evidence to support legal and regulatory reforms for sustainable hemp utilization.
- Promote gender inclusion, youth employment, and social enterprise development linked to restoration value chains.

8.3 Project Phases

Implementation will proceed through three progressive and interlinked phases:

8.3.1 Phase 1: Preparatory and Research Stage (Months 1–12)

This initial stage establishes the scientific, institutional, and community foundations for the pilot.

Key activities:

- Baseline assessments of soil and water contamination in selected sites (Western, Ashanti, and Eastern Regions).
- Stakeholder mapping and community consultations under the patronage of the Asantehene and traditional councils.
- Formation of a National Steering Committee (NACOC, EPA, MoFA, MESTI, MLNR, traditional authorities, universities, and civil-society representatives).
- Licensing procedures with NACOC for industrial hemp cultivation under research exemption.
- Establishment of experimental plots at university research farms for cultivar selection and metal-uptake trials.
- Development of environmental and social safeguard frameworks, including gender and child-protection protocols.

Expected outputs:

- Approved licenses and environmental permits.
- Baseline environmental and socio-economic datasets.
- Laboratory-confirmed selection of 2–3 hemp cultivars suited to Ghanaian soils.
- Operational partnerships with universities and local communities.

8.3.2 Phase 2: Pilot Implementation (Months 13–36)

The second phase transitions from research to field deployment across selected mining-affected districts.

Key activities:

- Establishment of 3–5 pilot sites (10–15 ha each) representing varied contamination levels and soil types.
- Application of hemp-based phytoremediation techniques combined with biochar amendments.
- Installation of biochar filtration trenches and reactive barriers in flooded pits and drainage zones.
- Capacity building for women's and youth cooperatives in nursery management, planting, and post-harvest biomass processing.
- Development of community awareness campaigns and participatory monitoring committees.
- Collaboration with the EPA and universities for ongoing environmental sampling (soil, water, and biomass).

Expected outputs:

- Demonstrated reduction in heavy-metal concentrations in soils and water (target: 20–40 % within two years).
- Documented increase in soil fertility and vegetation cover.
- Employment creation for 300–500 local workers, with at least 40 % female participation.
- Functional community cooperatives managing remediation plots and biochar units.

8.3.3 Phase 3: Scale-Up and Policy Integration (Months 37–60)

The final phase consolidates results, expands operations, and institutionalizes policy lessons.

Key activities:

- Replication of pilot results to new regions using lessons learned from Phase 2.
- Development of a National Phytoremediation and Industrial Hemp Policy Framework.
- Establishment of a National Centre for Phytoremediation Research and Training (in partnership with KNUST and EPA).
- Engagement with impact investors and climate-finance platforms for long-term scaling.
- Publication of policy briefs and best-practice manuals for regional dissemination.

Expected outputs:

- National policy framework endorsed by government and traditional authorities.
- Training curriculum and technical standards for phytoremediation.
- Expansion of remediated land to 500+ hectares.
- Integration of DECON HEMP into national green-economy programs.

8.4 Governance and Institutional Framework

Effective coordination will rely on a multi-tier governance structure ensuring accountability, scientific rigor, and community participation.

- **National Steering Committee (NSC)**
Chaired by MESTI, co-chaired by the Asantehene’s representative, and including EPA, NACOC, MoFA, MLNR, and academic and civil-society members.
Functions: strategic direction, inter-agency coordination, resource mobilization, and policy guidance.
- **Technical Implementation Unit (TIU)**
Hosted by the Environmental Protection Agency, responsible for day-to-day project management, procurement, and technical supervision.
Functions: site selection, monitoring, and data consolidation.
- **Regional Coordination Platforms (RCPs)**
Based within Regional Coordinating Councils, integrating district assemblies, traditional councils, and local NGOs.
Functions: community engagement, communication, and feedback handling.
- **Community Implementation Committees (CICs)**
Composed of local leaders, women’s and youth representatives, and cooperative managers.
Functions: field operations, grievance management, and maintenance of restored land.

This structure blends top-down coordination with bottom-up accountability, ensuring that decision-making is participatory and transparent.

8.5 Implementation Timeline

Phase	Duration (Months)	Core Activities	Lead Institutions
Phase 1 – Preparatory & Research	1–12	Baseline studies, licensing, partnerships, training	MESTI, EPA, NACOC, Universities
Phase 2 – Pilot Implementation	13–36	Field trials, community engagement, monitoring	EPA, MoFA, Traditional Authorities, NGOs
Phase 3 – Scale-Up & Policy Integration	37–60	Expansion, institutionalization, financing	NSC, Asantehene's Office, Development Partners

8.6 Resource Requirements (Indicative)

The DECON HEMP pilot requires a financing envelope sufficient to ensure scientific rigour, technical safety, and meaningful community participation. A detailed review of Ghanaian cost structures, logistics, and regulatory needs indicates an operational estimate of USD 12 million as considered realistic for a robust five-year program across 3–5 field sites (approx. 50–75 ha total).

Component	Estimated Cost (USD)	Notes / Responsible Parties
Baseline studies, research & licensing	1 750 000	Soil and water testing, heavy-metal and THC analyses, laboratory setup, licensing under Act 1019 – Universities, EPA, NACOC.
Site preparation & infrastructure	2 300 000	Earthworks, fencing, irrigation, access roads, security – EPA, Traditional Councils, District Assemblies.
Seed supply, cultivation & irrigation operations	2 000 000	Nursery development, cultivar trials, agronomic inputs, fuel – MoFA, Community Cooperatives.
Biochar units & water-filtration systems	2 200 000	Modular pyrolysis units (3–5 regions), filtration trenches, gas-capture filters – Local Enterprises, NGOs.
Capacity building, gender inclusion & training	1 400 000	Vocational courses, PPE, microfinance facilities, communications – MoGCSP, Civil Society Partners.
Monitoring, evaluation & learning (MEL)	950 000	Field and lab equipment, quarterly sampling, mid-term and final evaluations – EPA, Universities.
Policy development & dissemination	600 000	Legal reviews, workshops, documentation, policy briefs – MESTI, Steering Committee.
Contingency & administration	800 000	10–12 % inflation and logistics buffer, project management overhead – Project Secretariat.
Total (5 years)	12 000 000	Blended financing – National budget + development partners + impact investors.

Cost-Drivers and Assumptions

- Multi-site operations require **logistical mobility**, field vehicles, and security for fenced cultivation areas.
- **Scientific infrastructure** (portable XRF, ICP-MS analysis) and biochar emission-control systems represent significant capital items.
- **Community participation and gender inclusion** costs are elevated intentionally to ensure equitable benefit distribution.
- Inflationary trends ($\approx 10\text{--}15\%$ per year) are reflected in contingency allowances.

Financing Strategy

The budget will be implemented through a **blended-finance model**:

- **40 % Public Funding**
Government allocations via MoFA and MESTI.
- **40 % International Grants**
GEF, GCF, UNDP, and other development partners.
- **20 % Private Impact Capital**
ESG-compliant investors and carbon-credit programs.

Funds should be released in three tranches corresponding to project phases:

1. Start-up & Research (25 %),
2. Pilot Implementation (50 %),
3. Scale-up & Policy Integration (25 %).

This resource framework provides a realistic financial foundation for delivering a scientifically credible, socially inclusive, and policy-relevant demonstration of hemp-based remediation in Ghana.

8.7 Risk Management and Mitigation

Risk	Potential Impact	Mitigation Measures
Regulatory delays or conflicting interpretations	Project timeline disruption	Early legal consultation with NACOC and EPA; MoUs among agencies
Public resistance due to hemp stigma	Reduced participation	Continuous awareness campaigns and visible endorsement by Asantehene and NACOC
Extreme weather events or drought	Crop loss	Irrigation infrastructure, resilient cultivars, and seasonal planning
Insufficient funding	Implementation gaps	Blended financing and phased budgeting
Gender exclusion or local conflicts	Social tension	Transparent land allocation, grievance mechanisms, and inclusive governance

8.8 Monitoring, Evaluation, and Learning (MEL)

A robust MEL framework will ensure accountability and adaptive management. Indicators will include:

- reduction in heavy-metal concentration (soil and water),
- hectares of land restored,
- number of jobs created (by gender),
- household income improvements,
- policy instruments developed or revised, and
- community satisfaction and participation rates.

Environmental data will be collected quarterly, while socio-economic assessments will occur annually. Independent evaluations will be conducted at mid-term (Year 3) and end-line (Year 5). Results will feed into an open-access knowledge platform hosted by the EPA and universities, ensuring transparency and replicability.

8.9 Sustainability and Exit Strategy

Sustainability will depend on embedding DECON HEMP within national and local institutions. Key actions include:

- Integrating remediation into Ghana's Medium-Term Development Plans and the Green Ghana Initiative.
- Establishing local cooperatives as long-term land stewards, supported by microfinance and green entrepreneurship schemes.
- Training regional EPA offices and universities to continue research and monitoring beyond the pilot phase.
- Leveraging carbon-credit and biodiversity-offset mechanisms to finance maintenance and expansion.
- Encouraging private-sector engagement in processing remediated hemp biomass for bio-based industries.

Through these measures, DECON HEMP will transition from a donor-supported pilot into a self-sustaining national program, contributing to Ghana's environmental restoration and circular-economy ambitions.

8.10 Expected Outcomes

By the end of the five-year implementation cycle, DECON HEMP will have:

- **Demonstrated** measurable remediation of contaminated soils and water in mining regions;
- **Established** operational community cooperatives managing restored land;
- **Created** 500+ direct and 2,000+ indirect green jobs;
- **Strengthened** women's economic participation and environmental leadership;
- **Generated** scientific evidence and national policy frameworks for industrial hemp use;
- **Enhanced** Ghana's reputation as a leader in sustainable remediation and bioinnovation in West Africa.

9. Cost-Benefit and Financial Analysis

This chapter evaluates the financial and economic efficiency of the DECON HEMP pilot compared to conventional remediation methods. It estimates the direct and indirect costs, quantifies expected benefits in ecological, social, and economic terms, and assesses long-term financial sustainability. The analysis demonstrates that hemp-based phytoremediation offers a cost-effective, income-generating, and climate-aligned alternative to chemical or mechanical soil cleanup, while producing measurable co-benefits in employment, ecosystem services, and community well-being.

9.1 Methodological Framework

The cost–benefit assessment combines three analytical perspectives:

1. **Financial analysis**,
measuring direct project costs and potential revenue streams from biomass valorization and by-products.
2. **Economic analysis**,
evaluating broader social and environmental returns such as restored land value, reduced health costs, and job creation.
3. **Sustainability analysis**,
projecting long-term financial viability through value-chain development, carbon credits, and integration into Ghana’s green-economy programs.

The time horizon for analysis is **10 years**, covering the five-year pilot and an additional five-year post-project consolidation period. A discount rate of 6 % is used, consistent with Ghana’s public-investment guidelines.

9.2 Baseline: The Cost of Inaction

Ghana’s artisanal and small-scale gold mining (ASM) industry produces an estimated 30–40 tons of gold per year, but at tremendous environmental cost. EPA and World Bank data indicate that more than 190 000 acres (approx. 77,000 hectares) of land and numerous river systems are degraded. The average cost of conventional remediation (excavation, chemical stabilization, landfill disposal) ranges from **USD 250 000–350 000 per hectare**, in total of between around 19 bn to 27 bn USD — an amount prohibitive for large-scale rehabilitation.

Without intervention, the economic losses include:

- Devaluation of agricultural land and decline in productivity (estimated USD 100 million annually).
- Health expenditures linked to mercury and arsenic exposure, respiratory and neurological diseases (≈ USD 40 million annually).
- Reduced fishery and water-resource potential.
- Lost tax revenue and rural employment opportunities.

These figures underscore the urgent need for **low-cost, community-based remediation models** such as DECON HEMP.

9.3 Comparative Cost Analysis

Conventional remediation methods — excavation, soil washing, or chemical immobilization — are capital-intensive, requiring heavy equipment, chemical reagents, and landfill space. Their average cost per hectare typically exceeds USD 250 000, with limited socio-economic co-benefits.

Industrial hemp-based phytoremediation, by contrast, costs approximately USD 30 000–45 000 per hectare, including cultivation, biochar processing, and monitoring. Even with advanced biochar and safety systems, total lifecycle costs remain 70–80 % lower than conventional cleanup.

Method	Cost/ha (USD)	Main Outputs	Co-Benefits
Conventional chemical stabilization	250 000–350 000	Metal immobilization	None; soil remains sterile
Physical excavation & replacement	200 000–300 000	Clean fill soil	High energy use, carbon emissions
Hemp phytoremediation + biochar (DECON HEMP)	30 000–45 000	Metal extraction & stabilization	Restored soil fertility, employment, biomass value, carbon sequestration

Even at conservative uptake rates (20–40 % metal reduction over two years), the economic return through avoided health costs, land restoration, and value-chain creation far exceeds project expenditure.

9.4 Quantified Benefits

a. Direct Economic Benefits

- **Restored land value**
Each hectare remediated can regain 50–70 % of its pre-contamination market value (≈ USD 8 000–10 000 per ha). Across 75 ha, this equates to USD 600 000–750 000 in asset recovery.
- **Employment and income**
The project will create ≈ 500 direct and 2 000 indirect jobs. Assuming average annual income of USD 2 000, the cumulative wage injection over five years exceeds USD 10 million.
- **Value-added processing**
Biochar, fibres, and bio-oil could generate USD 200–400 per tonne of processed biomass, contributing approximately USD 1.5–2 million in potential revenue over the pilot period.

b. Indirect and Social Benefits

- **Reduced healthcare costs**
A 10–20 % decline in exposure-related illness could save USD 1.5–2 million per year in affected districts.
- **Improved agricultural productivity**
Restored soils can support mixed cropping after remediation, increasing food production by 20–30 % on rehabilitated lands.

- **Empowerment and inclusion**

Women's participation in cooperatives improves household income stability and educational outcomes for children.

c. Environmental and Climate Benefits

- **Carbon sequestration**

Each hectare of hemp absorbs $\approx 10\text{--}15$ tons CO₂ per year. Over 75 ha $\times$ five years, this equals $\approx 5\,000$ tons CO₂. At current and emerging carbon-market rates of USD 20–30 per ton CO₂, the project can generate between USD 100 000 and 150 000 annually in verified carbon-credit value, or approximately USD 0.5 – 0.7 million over the five-year pilot period..

- **Soil biodiversity recovery**

enhancing natural fertility and nutrient cycling.

- **Reduction in heavy-metal runoff**

and improved surface-water quality for downstream communities.

- **Long-term climate resilience**

as restored vegetation moderates microclimates and improves water infiltration.

These combined effects make DECON HEMP not only a remediation initiative but also a contributor to Ghana's Nationally Determined Contributions (NDCs) and its carbon-neutrality targets.

9.5 Cost–Benefit Ratio and Economic Return

Combining all quantifiable components yields the following summary (10-year horizon):

Item	Value (USD million)
Total project cost (5 years)	12.0
Direct economic benefits (employment, products, land value)	14.0
Indirect social & health benefits	8.0
Environmental & carbon benefits (at USD 20–30 / t CO ₂)	1.5
Total benefits	$\approx 23.5 - 24.0$
Net Present Value (NPV)	$\approx +7.5 - 8.0$ million
Benefit–Cost Ratio (BCR)	$\approx 2.0 : 1$

Even with conservative yield assumptions, the project now returns roughly two dollars of economic and social value for every dollar invested. The enhanced climate-benefit valuation also improves eligibility for international green-finance mechanisms and strengthens the case for public–private co-financing.

9.6 Financial Sustainability

The long-term viability of DECON HEMP depends on its integration into self-sustaining financing mechanisms:

1. **Circular-economy revenue**

Commercialization of safe biomass by-products (biochar, hempcrete, fibres) creates recurring income.

2. **Carbon and biodiversity credits**

Verified emission-reduction units can attract private impact finance.

3. **Public-private partnerships**

Local SMEs can operate biochar facilities and share profits under lease or franchise models.

4. **Microfinance schemes**

Women's and youth cooperatives can access revolving funds for hemp cultivation, supported by social-impact investors.

5. **Government co-financing**

Once national policy frameworks are in place, remediation can be integrated into MoFA and EPA annual budgets as part of Ghana's Green Recovery Plan.

Together, these instruments transform the project from donor-dependent to self-financing within 7–10 years, with reinvestment cycles for scaling across regions.

9.7 Sensitivity Analysis

Sensitivity testing using different discount rates and cost scenarios shows the project remains economically robust:

Variable	Scenario	BCR Result
Discount rate 6 % (base)	Medium benefit	1.9 : 1
Discount rate 8 %	Conservative benefit	1.6 : 1
Cost escalation +15 %	Medium benefit	1.7 : 1
Benefit escalation +10 %	Base cost	2.1 : 1

Sensitivity testing using different discount rates and cost scenarios shows the project remains economically robust, with a baseline Benefit–Cost Ratio of around 2 : 1. Even under high-cost or low-benefit assumptions, the Benefit–Cost Ratio stays above 1.5, confirming strong resilience.

9.8 Non-Monetary and Strategic Value

Beyond measurable financial returns, DECON HEMP delivers significant intangible benefits that strengthen Ghana's long-term sustainability agenda:

- **Policy innovation**

Establishes national precedents for regulated hemp use in environmental applications.

- **Scientific leadership**

Builds local expertise in phytotechnology and green chemistry.

- **Social cohesion**
Reinforces cooperation among traditional authorities, government, and citizens.
- **Reputation**
Positions Ghana as a regional model in nature-based solutions and circular bioeconomy policy.

These strategic impacts justify public investment even when direct cash returns are modest, as they enhance national resilience and international credibility.

9.9 Conclusions

The financial and economic analysis confirms that industrial hemp-based remediation is

- **technically viable,**
- **economically efficient, and**
- **socially transformative.**

With an estimated Benefit–Cost Ratio of nearly 2 : 1, the DECON HEMP pilot demonstrates superior value compared to conventional methods while generating sustainable livelihoods and climate co-benefits.

Scaling the model nationally could unlock cumulative savings of hundreds of millions of dollars in remediation and health costs over the next decade, transforming degraded mining landscapes into engines of inclusive green growth. The results provide a strong economic rationale for continued investment, public-private collaboration, and integration of phytoremediation into Ghana's environmental-management policy framework.

10. Risk Assessment

This chapter analyses potential risks associated with the design and implementation of the DECON HEMP project and outlines mitigation measures to ensure environmental safety, social inclusion, financial stability, and regulatory compliance. The assessment considers technical, institutional, and community dimensions, recognizing that successful remediation depends not only on biological performance but also on social acceptance, governance quality, and adaptive management. The approach applies the “**prevention–mitigation–adaptation**” model, ensuring risks are addressed proactively throughout the project life cycle.

10.1 Overview of Risk Framework

Risk management within DECON HEMP follows four guiding principles:

1. **Anticipation**
Risks are identified early, before they can escalate.
2. **Prevention**
Design measures minimize the probability of occurrence.
3. **Mitigation**
Contingency plans reduce the impact if risks materialize.
4. **Learning**
Continuous monitoring and feedback improve management over time.

Each category—environmental, social, technical, financial, institutional, and external—is assessed according to **likelihood** and **impact**, using a simple matrix:

- Low (L), Medium (M), High (H).
Risks rated “High” require immediate preventive measures or contingency protocols.

10.2 Environmental and Technical Risks

Risk	Description	Likelihood	Impact	Mitigation / Response Measures
Soil or water recontamination	Contaminated biomass or runoff could reintroduce metals into the environment if not safely handled.	M	H	Strict biomass management protocols: controlled pyrolysis, ash containment, monitoring of effluents, and EPA supervision.
Crop failure due to climatic stress	Drought or excessive rainfall may reduce biomass yield.	M	M–H	Use drought-tolerant cultivars, establish drip irrigation, schedule planting with rainfall cycles, maintain seed reserves.

Mercury volatilization during pyrolysis	Processing Hg-contaminated biomass could release vapours.	L–M	H	Install gas-phase activated-carbon filters, ensure closed pyrolysis systems, periodic air-quality monitoring.
Biochar leaching or secondary contamination	Improperly stored or applied biochar may release bound metals.	L	M	Use laboratory-certified biochar with documented immobilization efficiency; EPA-approved application rates.
Invasive or cross-pollination risk	Hemp cultivars could hybridize with wild cannabis varieties.	L	M	Controlled seed sourcing, fencing, and collaboration with NACOC for compliance monitoring.
Laboratory and field safety	Exposure to contaminants during testing or harvesting.	M	M	Provision of PPE, safety training, and insurance for field workers and technicians.

Environmental and technical risks are moderate but controllable through engineering design, regulatory oversight, and staff training. The project's closed-loop approach (industrial hemp–biochar–monitoring) minimizes the possibility of secondary pollution.

10.3 Social and Community Risks

Risk	Description	Likelihood	Impact	Mitigation / Response Measures
Community resistance due to misunderstanding of hemp	Fear of association with narcotics or moral objections.	M	H	Targeted awareness campaigns, involvement of Asantehene and religious leaders, transparent legal communication.
Land-access disputes	Overlapping claims between chiefs, families, and government.	M	H	Negotiated land-use agreements, documentation under customary law, mediation via traditional councils and district assemblies.
Gender exclusion or elite capture	Male dominance or elite monopolization of benefits.	M	H	Quotas for women's participation, public disclosure of land allocations, cooperative-based management.

Child labour or unsafe working conditions	Potential exploitation due to poverty pressures.	L–M	H	Enforce labour standards, periodic inspections, partnership with social-protection agencies.
Loss of livelihood during remediation period	Farmers may lose short-term income from degraded lands under restoration.	M	M	Transitional livelihood support (cash-for-work, intercropping, short-cycle vegetables) until restoration is complete.
Unmet community expectations	Unrealistic hopes for rapid financial gain.	M	M	Continuous consultation, transparent progress reporting, and participatory evaluation.

Social risks are moderate but highly sensitive. Success depends on trust, transparency, and inclusion, which are secured through the communication plan and strong participation of traditional authorities and women's groups.

10.4 Policy and Regulatory Risks

Risk	Description	Likelihood	Impact	Mitigation / Response Measures
Regulatory delay or ambiguity	Incomplete subsidiary legislation under Act 1019 may slow licensing.	M	H	Early engagement with NACOC and MESTI; legal MoUs defining pilot status; policy advisory role for Steering Committee.
Inter-agency overlap	EPA, NACOC, and MoFA mandates may conflict.	M	M	Establish National Steering Committee with clear terms of reference and decision-making hierarchy.
Changes in government policy	Political transitions may affect support.	M	M	Institutionalize project under long-term national strategies (NDCs, Green Ghana Initiative); diversify partnerships beyond political cycles.
Weak enforcement of environmental regulations	Local authorities may lack resources to supervise.	H	M	Capacity building and resource provision for regional EPA offices and district assemblies.

Legal and institutional risks are moderate but manageable with proactive coordination and formalized agreements among all regulatory entities.

10.5 Financial and Economic Risks

Risk	Description	Likelihood	Impact	Mitigation / Response Measures
Funding shortfall or delays	Donor or government disbursements may lag.	M	H	Multi-source financing, phased budgeting, and reserve fund of 10 %.
Cost escalation (inflation, imports)	Exchange-rate volatility increases input costs.	H	M	Local procurement where possible, price hedging, contingency buffer.
Market fluctuations for biomass products	Biochar or hemp-fibre prices vary.	M	M	Diversify products (biochar, bio-oil, fibre composites), develop guaranteed offtake agreements.
Carbon-credit price volatility	Shifts in voluntary-market prices.	M	M	Secure long-term forward contracts at fixed rates; register under verified standards (e.g., Verra, Gold Standard).

Financial risks are primarily macroeconomic. Flexible financing and blended-fund design reduce exposure. The inclusion of carbon and value-chain revenues adds resilience.

10.6 Health, Safety, and Environmental (HSE) Risks

Health and safety risks concern exposure to contaminants, mechanical injuries, or air emissions. Mitigation will rely on strict compliance with EPA and Ghana Labour Act standards:

- **Mandatory Personal Protective Equipment (PPE)** for all workers.
- **Regular health screening** (baseline and annual).
- **Hazardous-material protocols** for sample handling and biochar operation.
- **Emergency response plans** and first-aid kits at each site.
- **Insurance coverage** for workers and assets.

These measures will be integrated into a formal HSE Management Plan, reviewed annually by the Technical Implementation Unit.

10.7 Environmental and Social Safeguards

DECON HEMP adheres to national and international safeguard standards, ensuring “do no harm” principles. Key policies include:

- **Environmental and Social Impact Assessment (ESIA)**
Conducted before site operations, following EPA guidelines.
- **Gender Equality and Social Inclusion (GESI)**
Equal access for women, youth, and vulnerable groups.
- **Grievance Redress Mechanism (GRM)**
Accessible reporting channels for community concerns.

- **Free, Prior, and Informed Consent (FPIC)**
For all land allocations and major project decisions.
- **Monitoring and Disclosure**
Regular publication of environmental data and social indicators.

These safeguards align DECON HEMP with the IFC Performance Standards (1–8) and Ghana’s EPA Act (Act 490).

10.8 External and Climatic Risks

Risk	Description	Likelihood	Impact	Mitigation / Response Measures
Extreme weather (floods, drought)	Increasing climate variability threatens crop cycles.	M–H	H	Diversified cropping calendar, drought-tolerant cultivars, supplementary irrigation, integration with national adaptation plans.
Pest or disease outbreak	Infestation could damage hemp crops.	M	M	Integrated pest management, biological control, and crop rotation.
Public controversy or misinformation	Media or political actors may misrepresent the project.	M	M	Transparent communications strategy, public briefings by NACOC and the Asantehene’s Office.
Regional insecurity	Potential disruptions from illegal mining groups resisting rehabilitation.	L–M	H	Collaboration with district security councils, community policing, and awareness mediation by traditional authorities.

External risks highlight the need for adaptive management and close coordination with national disaster and security agencies. The Asantehene’s patronage and community participation are strong deterrents to sabotage or misinformation.

10.9 Risk Monitoring and Adaptive Management

Risk management is not static; it evolves through continuous feedback loops. The Technical Implementation Unit will maintain a Risk Register updated quarterly, ranking risks by priority and documenting mitigation status.

Annual independent audits will evaluate the adequacy of measures and recommend improvements. Community committees will feed local observations into this system, ensuring that early warnings from the ground inform project decisions in real time. This participatory approach ensures that DECON HEMP remains agile, accountable, and resilient against unforeseen challenges.

10.10 Overall Risk Profile

Risk Category	Average Likelihood	Average Impact	Residual Risk after Mitigation
Environmental & Technical	Medium	High	Moderate
Social & Community	Medium	High	Moderate
Policy & Regulatory	Medium	Medium	Low–Moderate
Financial & Economic	Medium	Medium	Low–Moderate
Health & Safety	Medium	High	Low
External & Climatic	Medium	High	Moderate

After mitigation, the overall project risk level is **moderate**, acceptable within international development-financing standards. Strong community ownership, the Asantehene’s patronage, and transparent governance provide substantial social and institutional risk buffers.

10.11 Conclusion

The risk analysis confirms that DECON HEMP is a manageable and resilient project. Most identified risks are moderate in likelihood and can be effectively mitigated through proactive planning, community engagement, and institutional coordination. Environmental and social safeguards embedded in the design ensure compliance with both Ghanaian law and international best practice.

Far from being a vulnerability, the project’s multidisciplinary structure — linking science, tradition, and governance — serves as its greatest protection against failure. By anticipating challenges, building trust, and institutionalizing adaptive management, DECON HEMP establishes a framework for safe, equitable, and sustainable implementation across Ghana’s mining landscapes.

11. Monitoring and Evaluation Framework

This chapter outlines the system for monitoring, evaluation, and learning (MEL) within the DECON HEMP project. It defines the objectives, indicators, responsibilities, and data-collection methods required to ensure that project implementation is transparent, evidence-based, and adaptive. The framework integrates environmental, social, economic, and governance indicators—capturing both quantitative results and qualitative transformation at community and institutional levels. It aligns with Ghana’s national monitoring standards and the Sustainable Development Goals (SDGs), ensuring that outcomes can be reported domestically and internationally.

11.1 Purpose and Principles

The Monitoring and Evaluation (M&E) system serves four main purposes:

1. **Accountability**
Demonstrate responsible use of public and donor resources through measurable results.
2. **Learning**
Generate knowledge to refine techniques, policies, and community engagement strategies.
3. **Transparency**
Provide reliable data to stakeholders, fostering trust and public support.
4. **Replication**
Build a body of evidence to support scaling across Ghana and potentially other African countries.

The M&E framework is guided by five principles:

- **Participation**
Communities and cooperatives actively collect and interpret data.
- **Triangulation**
Multiple data sources (field surveys, laboratory analysis, remote sensing) ensure accuracy.
- **Disaggregation**
Indicators are gender- and age-disaggregated where applicable.
- **Frequency**
Regular monitoring enables early problem detection and course correction.
- **Alignment**
Indicators correspond with national environmental and development targets (NDCs, NCCP, SDGs).

11.2 Institutional Responsibilities

Monitoring and evaluation are implemented through a **multi-level structure** that mirrors the governance arrangements described in Chapter 8.

Institution / Actor	Role and Responsibilities
Technical Implementation Unit (EPA)	Operates the MEL system, compiles quarterly and annual reports, manages central database.
Universities (KNUST, University of Ghana, UDS)	Conduct laboratory testing, independent verification of soil and water samples, and methodological research.
Community Implementation Committees (CICs)	Collect field data (growth, biomass, participation), report incidents, maintain community scorecards.
National Steering Committee (NSC)	Reviews quarterly and annual MEL reports, validates progress against targets, and recommends strategic adjustments.
External Evaluators	Conduct mid-term (Year 3) and final (Year 5) evaluations, ensuring objectivity and alignment with donor standards.
Development Partners	Participate in joint supervision missions and thematic learning reviews.

This arrangement guarantees that monitoring is both scientifically rigorous and socially grounded, with results validated at multiple levels.

11.3 Monitoring Dimensions

The MEL framework covers four interrelated dimensions, reflecting the project's holistic objectives.

- 1. Environmental performance**
Reduction of contaminants, soil restoration, and biodiversity recovery.
- 2. Social and economic inclusion**
Employment generation, gender participation, community satisfaction.
- 3. Institutional strengthening**
Governance, coordination, and policy influence.
- 4. Financial and operational efficiency**
Budget use, cost control, and revenue generation from value-added activities.

Each dimension is linked to specific indicators, measurable targets, and data-collection tools.

11.4 Key Indicators and Targets

Dimension	Indicator	Baseline	Target (Year 5)	Data Source / Frequency
Environmental	Average reduction of heavy-metal concentrations (Pb, Cd, Hg, As) in soil and water	> 5× permissible limits	30–50 % reduction	Quarterly sampling, laboratory analysis (EPA, Universities)

	Percentage of remediated land meeting EPA safety thresholds	0 %	≥ 70 %	Annual lab certification
	Carbon sequestration achieved (tons CO ₂ equivalent)	0	5 000 t CO ₂	Annual field data + carbon registry
	Vegetation cover (NDVI index)	Degraded baseline	+40 % increase	Remote sensing (GIS mapping)
Social / Economic	Number of direct jobs created	0	≥ 500 (40 % women)	Project records, cooperative reports
	Number of indirect jobs and SMEs supported	0	≥ 2 000	Annual surveys
	Women's participation in decision-making bodies	<10 %	≥ 40 %	Attendance registers, NSC minutes
	Youth participation (ages 18–35)	<10 %	≥ 35 %	Cooperative membership logs
Health / Safety	Reported workplace accidents	—	0 serious accidents	HSE logs, quarterly
	Reduction in exposure-related illnesses (mercury, arsenic)	High incidence	≥ 15 % decrease	Health-centre records, baseline vs. endline survey
Institutional	Number of inter-agency agreements (MoUs) signed	0	≥ 5	NSC reports
	Policy instruments influenced or adopted	0	≥ 2 national instruments	Government gazette, policy briefs
Financial	Disbursement rate against planned budget	0 %	≥ 95 %	Quarterly financial reports
	Value of by-product revenues (biochar, fibre)	0	USD 1.5–2 million cumulative	Cooperative sales reports
	Carbon-credit revenue	0	≥ USD 0.5 million	Verified carbon registry reports

These indicators are complemented by qualitative metrics — such as community satisfaction levels, knowledge retention, and perception of hemp legality — measured through focus groups and narrative reporting.

11.5 Data Collection and Verification

Data will be collected using a combination of quantitative and qualitative tools:

- **Field Sampling**
Soil and water analyses conducted quarterly following EPA laboratory protocols.
- **Remote Sensing**
Satellite imagery and drones will monitor vegetation recovery and land-use change.
- **Household Surveys**
Annual socio-economic and health surveys in participating communities.
- **Administrative Records**
Employment, training, and expenditure data maintained by cooperatives and implementing agencies.
- **Participatory Monitoring**
Community members record daily field observations, weather conditions, and crop performance using standardized logbooks.
- **Independent Verification**
External evaluators cross-check data through field visits and sample re-testing.

To guarantee data integrity, a central digital MEL database will be developed by the EPA, integrating GIS layers, lab data, and socio-economic indicators. Regular audits will ensure accuracy and reliability.

11.6 Evaluation Schedule

Evaluation Type	Timing	Lead Agency	Purpose
Baseline Study	Months 1–6	EPA & Universities	Establish environmental, social, and economic baselines.
Quarterly Monitoring Reports	Every 3 months	TIU (EPA)	Track progress and flag operational issues.
Annual Review Meetings	Yearly	NSC	Assess annual targets, approve work plan and budget.
Mid-Term Evaluation	Month 30 (Year 3)	Independent Evaluator	Assess performance, cost-effectiveness, and recommend course corrections.
Final Evaluation	Month 60 (Year 5)	Independent Evaluator	Determine achievement of objectives, sustainability, and scalability.
Post-Project Impact Assessment	Year 8–10	Universities & EPA	Measure long-term ecological and social benefits.

Each evaluation will generate detailed reports shared with stakeholders and published on a public-access platform to promote transparency and learning.

11.7 Learning and Knowledge Management

DECON HEMP is conceived as a **living laboratory** for sustainable remediation. Knowledge management will ensure that experiences, data, and lessons learned are captured, disseminated, and used to improve policy and practice.

Key tools include:

- **Annual Knowledge Workshops**
Bring together scientists, farmers, policymakers, and traditional leaders to share results and innovations.
- **Policy Briefs and Technical Manuals**
Summarize best practices for scaling up.
- **Academic Publications**
Peer-reviewed studies by Ghanaian universities enhance global visibility.
- **Community Exchange Visits**
Farmers and cooperatives from different regions share experiences.
- **Digital Repository**
Open-access portal with reports, maps, and datasets maintained by the EPA and universities.

This knowledge ecosystem transforms DECON HEMP from a pilot into a **national learning platform for green innovation**.

11.8 Feedback, Transparency, and Adaptive Management

M&E results will feed into an adaptive management cycle, ensuring that lessons are immediately applied to decision-making. Each quarterly report will include:

- Updated risk register (from Chapter 10).
- Status of indicators relative to targets.
- Financial and operational analysis.
- Recommendations for corrective actions.

Findings will be presented at quarterly stakeholder review meetings, enabling rapid response to emerging challenges. Public dashboards and summary briefs will make progress visible to communities, the media, and funding partners, reinforcing accountability.

11.9 Alignment with National and International Frameworks

The DECON HEMP MEL system aligns with:

- Ghana's Medium-Term National Development Policy Framework (MTNDPF) and the National Climate Change Policy (NCCP).
- The EPA Environmental Data Management System (EDMS) for integrated reporting.
- The SDG indicator framework, contributing particularly to:
 - SDG 3 (Good Health and Well-Being),
 - SDG 5 (Gender Equality),
 - SDG 8 (Decent Work and Economic Growth),
 - SDG 13 (Climate Action), and
 - SDG 15 (Life on Land).

By integrating these systems, the project ensures data comparability and policy relevance at both national and international levels.

11.10 Expected Outcomes of the MEL System

- Comprehensive evidence base on the performance and scalability of hemp-based remediation.

- Strengthened institutional capacity for environmental monitoring and participatory evaluation.
- Transparent reporting and improved public confidence in environmental governance.
- Real-time learning loops that enhance efficiency and reduce operational risks.
- Data-driven foundation for policy dialogue and future investment mobilization.

11.11 Conclusion

The Monitoring and Evaluation Framework transforms DECON HEMP from a project into a learning and accountability mechanism. By integrating scientific precision with community participation, it ensures that results are credible, inclusive, and actionable. This system not only measures success but creates it—through continuous reflection, transparency, and adaptation.

In doing so, DECON HEMP will set new standards for how environmental restoration projects in Ghana and West Africa are monitored, evaluated, and communicated.

12. Communication and Dissemination Plan

This chapter presents the strategy for communicating the objectives, progress, and results of the DECON HEMP initiative to diverse audiences. It defines the communication goals, identifies target stakeholders, and outlines tools and channels for dissemination at local, national, and international levels. The plan ensures that information flow is transparent, inclusive, and aligned with Ghana's public-communication standards and international best practices in environmental governance. Effective communication is both a management tool and a social process—essential for building trust, ensuring legitimacy, and creating an enabling environment for scaling up phytoremediation as a recognized policy and economic solution.

12.1 Communication Objectives

The communication strategy supports five overarching objectives:

1. **Inform**
Ensure that stakeholders understand the project's goals, methods, and achievements.
2. **Engage**
Encourage active participation by communities, government institutions, and partners.
3. **Educate**
Increase public awareness of industrial hemp's legal, environmental, and economic roles.
4. **Influence**
Shape public policy and perception to support sustainable remediation and bioeconomy development.
5. **Celebrate**
Highlight Ghana's leadership in pioneering a culturally rooted, science-based solution for environmental restoration.

12.2 Guiding Principles

Communication within DECON HEMP follows key principles of good governance:

- **Transparency**
All stakeholders have access to accurate and timely information.
- **Inclusiveness**
Messages are tailored to gender, age, literacy levels, and language diversity.
- **Credibility**
Information is verified by technical experts and national authorities before release.
- **Cultural sensitivity**
Messages respect local traditions, moral norms, and the authority of traditional leaders.
- **Two-way communication**
Feedback from communities and partners shapes content and delivery.
- **Consistency**
Clear differentiation between industrial hemp and narcotic cannabis in all public materials.

12.3 Target Audiences

Stakeholder Group	Information Needs / Interests	Communication Channels
Local communities (farmers, women, youth)	How the project benefits livelihoods, safety of hemp, participation opportunities.	Community radio, posters, town-hall meetings, participatory videos.
Traditional leaders (Asantehene, queen mothers, chiefs)	Cultural and moral justification for project, status updates, visibility of traditional leadership.	Council meetings, ceremonial events, press briefings.
Government institutions (EPA, MoFA, MESTI, NACOC)	Evidence-based results, regulatory compliance, policy recommendations.	Technical reports, policy briefs, inter-ministerial workshops.
Academia and research institutions	Data access, research collaboration, publication opportunities.	Open data repository, conferences, joint studies.
Private sector and investors	Market prospects, legal clarity, ESG benefits, carbon credits.	Investor briefings, business roundtables, promotional materials.
Civil society and NGOs	Social and environmental outcomes, gender inclusion, transparency.	NGO networks, newsletters, webinars.
Media (national and international)	Stories, visuals, and scientific validation for accurate reporting.	Press releases, media field visits, training workshops.
International community and donors	Policy innovation, scalability, alignment with SDGs and climate finance.	High-level presentations, global conferences, online platforms.

12.4 Communication Channels and Tools

Local and Community-Level Tools

- **Community radio programs**
in Twi, Fante, and local dialects explaining the environmental role of hemp and biochar.
- **Information kiosks**
at project sites displaying progress data, safety notices, and local success stories.
- **Participatory theatre and storytelling**
engaging youth and schools in dramatizing the “healing of the land.”
- **Field days and demonstration plots**
where farmers observe results and share experiences.

National-Level Tools

- **Press releases and media kits**
issued jointly by the EPA and the Office of the Asantehene to ensure authoritative communication.
- **Policy briefs**
summarizing findings for ministries, parliamentarians, and development partners.

- **National conferences and exhibitions**
for instance at the Ghana Green Business Forum or the Environmental Sustainability Fair.
- **Academic symposia**
led by KNUST and the University of Ghana to present research outputs.

Digital and International Tools

- **Official website and social media platforms (X, Facebook, LinkedIn)**
sharing project milestones, visuals, and infographics.
- **Interactive online dashboard**
integrating GIS data, soil metrics, and employment indicators for public access.
- **Video documentaries**
in English and local languages for broadcasting and global dissemination.
- **Participation in international forums**
such as COP meetings, UNEA, and the African Green Growth Forum to showcase Ghana's innovation in hemp remediation.

12.5 Branding and Messaging

DECON HEMP's communication identity will emphasize renewal, safety, and national pride. Key narrative themes include:

- "Healing the Land, Empowering the People."
- "From Pollution to Prosperity: Ghana's Green Transformation."
- "Industrial Hemp: Legal, Safe, and Sustainable."

Visual materials will use Ghana's national colours combined with green and earthy tones symbolizing regeneration. The logo and graphic design will be simple, recognizable, and suitable for both print and digital use.

All materials will carry official endorsements from the Environmental Protection Agency and the Asantehene's Office to ensure public credibility.

12.6 Stakeholder Engagement and Feedback Mechanisms

The communication plan links directly to the project's grievance and feedback systems (see Chapter 6.7). Community members, cooperatives, and local institutions can contribute feedback through:

- Suggestion boxes at field sites,
- Periodic community dialogues and radio call-in programs,
- Online forms on the project website,
- Focus-group discussions facilitated by NGOs and youth leaders.

Feedback will be analysed quarterly by the Technical Implementation Unit and summarized in public reports. Responses will be incorporated into adaptive management decisions, reinforcing accountability and two-way dialogue.

12.7 Communication Responsibilities

Entity	Role
Technical Implementation Unit (EPA)	Lead communications and maintain the central information platform.
Office of the Asantehene and Traditional Councils	Provide public endorsements, organize community ceremonies, and act as spokespersons for moral and cultural legitimacy.
MESTI and MoFA	Communicate policy relevance and national impact.
Universities and Research Partners	Disseminate scientific data and publications.
Civil Society Organizations	Facilitate local communication, gender-sensitive outreach, and social accountability.
Media Relations Consultant	Support professional branding, training of journalists, and crisis communication.

This structure ensures that communication is coordinated, coherent, and multidimensional, linking community dialogue with policy visibility and global outreach.

12.8 Phased Implementation of the Communication Plan

Phase	Timeline	Main Activities
Phase 1	Months 1–12	Project launch, awareness campaigns, baseline perceptions survey, media engagement, establishment of communication platforms.
Phase 2	Months 13–36	Regular updates, success-story documentation, policy dialogues, local education programs, and national exhibition events.
Phase 3	Months 37–60	International dissemination, publication of final reports and documentaries, replication toolkit for other regions.

At each phase, communication outputs will be evaluated using audience reach, feedback quality, and media-coverage analysis.

12.9 Risk Management in Communication

Potential Risk	Mitigation Strategy
Misrepresentation of hemp as narcotic cannabis	Consistent messaging on legality, endorsement from NACOC and Asantehene, training for journalists.
Information fatigue or community disengagement	Interactive formats (radio, drama, visual storytelling) rather than one-way communication.

Political misuse of project visibility	Maintain non-partisan communication, focus on technical and cultural legitimacy.
Data misinterpretation	Release verified information only after cross-agency validation; clear data-visualization guidelines.
Cybersecurity threats (digital platforms)	Secure hosting, data encryption, and regular audits.

12.10 Monitoring and Evaluation of Communication

Effectiveness will be tracked through:

- **Quantitative metrics**
Number of publications, media mentions, website visits, training participants.
- **Qualitative metrics**
Changes in community perception, stakeholder satisfaction, and policy discourse.
- **Annual communication audits**
Conducted by an external media expert to assess coherence, inclusiveness, and impact.

Lessons from communication monitoring will feed into adaptive management cycles (see Chapter 11.8).

12.11 Expected Outcomes

- Increased public awareness and acceptance of industrial hemp as a legal, safe environmental tool.
- Enhanced participation and trust among communities, government, and investors.
- Strengthened visibility of Ghana as a regional leader in green remediation and circular bioeconomy.
- Transparent documentation of project results accessible to all stakeholders.
- Improved policy dialogue and replication potential across West Africa.

12.12 Conclusion

Effective communication is integral to DECON HEMP's success. By transforming complex scientific and policy concepts into accessible narratives, the project bridges the gap between research, governance, and everyday experience. Transparent and inclusive communication will not only inform but inspire — a catalyst for national pride and collective action to restore Ghana's degraded landscapes.

Through consistent storytelling and participatory outreach, DECON HEMP will become a national symbol of ecological renewal and social innovation, demonstrating how science, culture, and leadership can unite to heal both land and people.

13. Conclusion and Recommendations

This final chapter synthesizes the core findings of the DECON HEMP Feasibility Study, summarizing the project's environmental, technical, social, and economic rationale. It presents conclusions and strategic recommendations for implementation, scaling, and policy integration.

A concise overview of key findings is provided first for evaluators and policymakers.

13.1 Key Findings (Executive Summary)

1. Environmental Feasibility

Industrial hemp (*Cannabis sativa L.*) has demonstrated credible capacity to absorb and stabilize heavy metals—including mercury (Hg) and arsenic (As)—in contaminated soils. Laboratory and field studies (Siegel et al., 1988; Altmaier, 2021; Güler & Zengin, 2022; Kumar et al., 2022; Sward et al., 2025) report reductions of up to 60 % in metal mobility, particularly when combined with biochar amendments. These results establish a sound basis for DECON HEMP to validate hemp–biochar remediation under Ghanaian conditions, turning degraded mining land into regenerative livelihoods.

2. Complementary Biochar Application

Biochar enhances cation exchange capacity, binds metals, and prevents leaching. When produced from harvested industrial hemp biomass, it safely immobilizes contaminants and sequesters carbon—creating a closed, low-waste remediation cycle aligned with circular-economy principles.

3. Economic Efficiency

Industrial hemp-based remediation costs USD 30 000–45 000 per ha, roughly 70–80 % less than conventional cleanup. Over a 10-year socio-economic horizon (five-year pilot + five-year post-impact) and a 6 % discount rate, total discounted benefits ($\approx$ USD 23–24 million) exceed costs ($\approx$ USD 12 million), yielding a Net Present Value of USD 7.5–8 million and a Benefit–Cost Ratio of $\approx 2 : 1$ — clear evidence of strong public-investment efficiency.

4. Legal and Policy Readiness

The Narcotics Control Commission Act (Act 1019) allows controlled industrial-hemp cultivation. Coordination among NACOC, EPA, MESTI, MoFA, and traditional authorities enables lawful implementation under research and environmental licences, positioning DECON HEMP within Ghana's evolving green-economy framework.

5. Social Inclusion and Gender Empowerment

Women and youth are central to implementation. The project guarantees at least 50 % female participation, secures land-use rights for women's cooperatives, and offers vocational and entrepreneurial training — transforming those most affected by degradation into leaders of ecological recovery.

6. Community Acceptance and Cultural Legitimacy

The patronage of the Asantehene and the Asanteman Council would provide unmatched moral authority. Traditional and faith leaders translate industrial hemp remediation into a

culturally meaningful act of stewardship, ensuring trust, ownership, and long-term social acceptance.

7. **Financial Viability**

The revised five-year pilot budget of ≈ USD 12 million is feasible through blended financing (40 % public, 40 % international grants, 20 % impact capital). The model complements Ghana's Green-Economy and NDC financing frameworks and can attract private ESG investment.

8. **Risk Management and Safeguards**

Environmental, social, and policy risks are moderate and controllable. Mitigation includes regulated pyrolysis for contaminated biomass, gender-safe working conditions, transparent land agreements, and coordinated oversight by the EPA and NACOC.

9. **Monitoring, Evaluation, and Learning**

A comprehensive MEL system—combining environmental, social, and governance indicators—ensures data-driven management, transparency, and adaptive learning through quarterly monitoring and public reporting.

10. **Strategic Positioning**

DECON HEMP positions Ghana as a regional leader in circular, nature-based remediation, contributing directly to SDGs 3, 5, 8, 12, 13 and 15 and aligning with ECOWAS and African Union green-growth strategies.

13.2 Synthesis and Overall Conclusion

The feasibility study confirms that DECON HEMP is technically sound, economically viable, socially inclusive, and institutionally implementable. It unites science, culture, and governance in a single restorative framework that addresses one of Ghana's most urgent challenges — land degradation from artisanal gold mining — through regenerative, low-carbon innovation.

By replacing extractive activities with restorative livelihoods, DECON HEMP offers a model for a just ecological transition. Its successful implementation will validate industrial hemp and biochar as practical tools for heavy-metal remediation and sustainable job creation, providing a replicable blueprint for other African mining regions.

13.3 Strategic Recommendations

1. **Institutional and Policy Framework**

- Establish a **National Steering Committee on Phytoremediation and Industrial Hemp**, chaired by MESTI with participation from EPA, NACOC, MoFA, MLNR, and the Asantehene's Office.
- Develop **subsidiary regulations** under Act 1019 covering environmental and industrial applications.
- Integrate hemp-based remediation into the **National Climate Change Policy (NCCP)** and **Green Ghana Initiative**.
- Create a **National Centre for Phytoremediation Research and Training** hosted by KNUST and the EPA.

2. Implementation and Financing

- Apply a **blended-finance model** (40 % public, 40 % development partners, 20 % private/impact investors).
- Launch 3–5 pilot sites in Western, Ashanti, and Eastern Regions.
- Establish a **Phytoremediation Fund**, financed through carbon credits, ESG bonds, and CSR allocations from the mining sector.
- Encourage private partnerships for biochar, fibre, and composite production.

3. Community and Social Development

- Expand women's cooperatives with secured land tenure, microcredit, and processing equipment.
- Develop **Youth Green-Skill Programs** for training in biochar technology, soil science, and green entrepreneurship.
- Maintain participatory monitoring and grievance mechanisms to ensure inclusivity.
- Introduce environmental education in local schools.

4. Research and Innovation

- Conduct controlled field trials quantifying Hg and As uptake under Ghanaian soil conditions
- Investigate **biochar filtration** and **microbial consortia** for enhanced remediation.
- Publish results through peer-reviewed journals and open-access databases to strengthen Ghana's leadership in phytotechnology.

5. Communication and International Visibility

- Disseminate validated results through digital platforms, policy briefs, and international conferences.
- Present Ghana's model at AU, ECOWAS, and UNFCCC events to attract replication funding.
- Develop a **replication toolkit** for adaptation in other West African mining regions.

13.4 Outlook and Next Steps

- **National Validation Workshop**
with government, traditional leaders, and donors to endorse the pilot plan.
- **Detailed Project Design Document (PDD)**
including ESIA, financing plan, and institutional agreements.
- **Regulatory Licensing**
with NACOC and EPA for cultivation, transport, and biomass processing.
- **Pilot Launch**
under the patronage of the Asantehene to highlight cultural and national ownership.
- **Knowledge Dissemination and Policy Dialogue** to integrate lessons into national and regional frameworks.

13.5 Final Statement

DECON HEMP demonstrates that restoring land and restoring livelihoods are inseparable goals. Through the synergy of industrial hemp, biochar, and community empowerment, Ghana can transform polluted mining zones into engines of inclusive green growth.

The convergence of scientific innovation, traditional authority, and participatory governance makes this initiative uniquely transformative — an emblem of Ghana's capacity to lead Africa's green transition.

DECON HEMP stands as a proof of concept for regenerative development: healing the land, empowering people, and redefining prosperity through sustainability.

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Summary Note

This reference list consolidates peer-reviewed studies, technical reports, and policy documents from 1988–2025, forming the scientific and regulatory foundation for the DECON HEMP initiative. It demonstrates the empirical validation of industrial hemp as a phytoremediation crop for mercury- and arsenic-contaminated soils, the complementary role of biochar in heavy-metal stabilization, and alignment with Ghana's national and international sustainability frameworks.