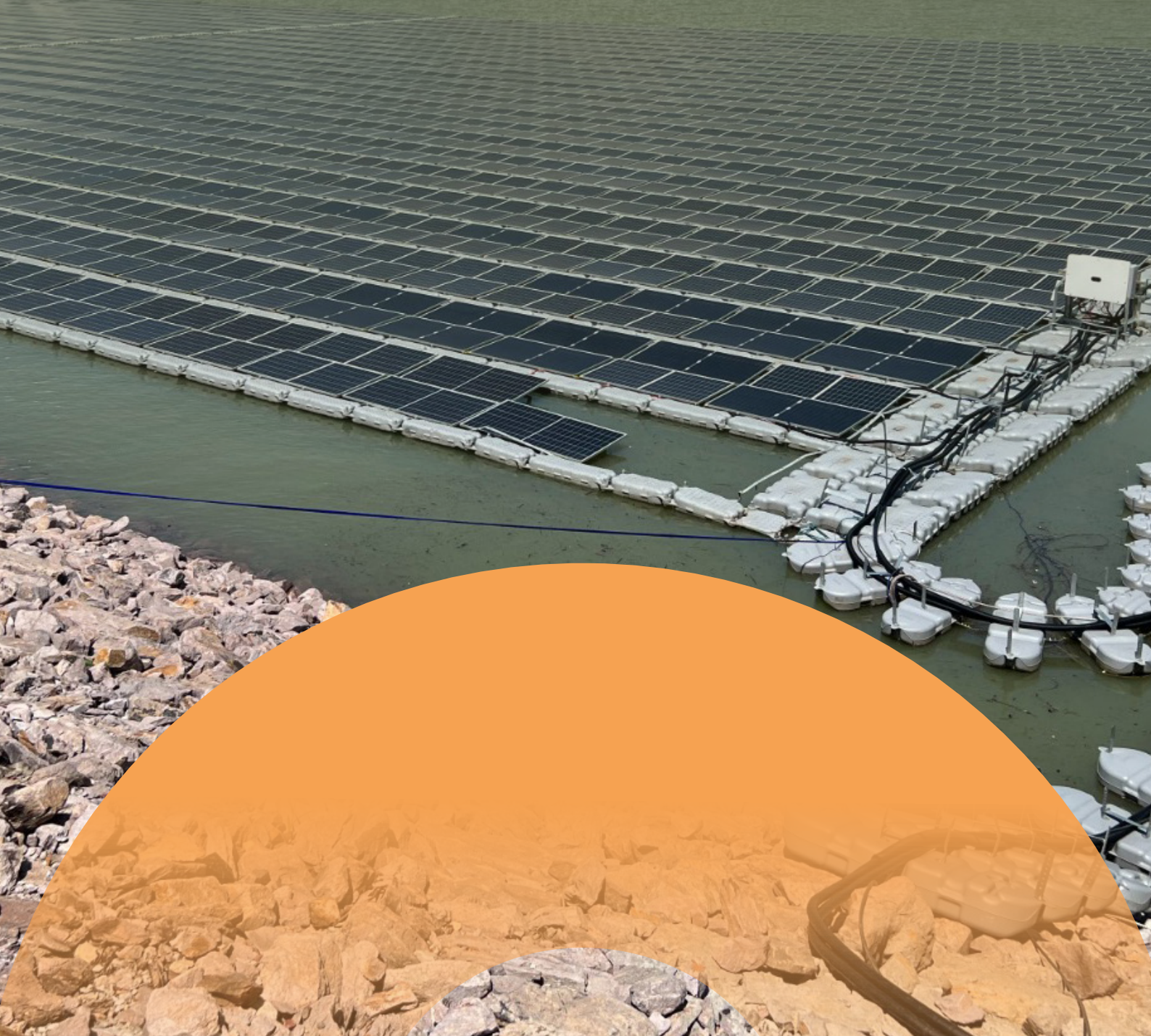




GOVERNMENT
OF GHANA

GHANA NATIONAL NET-ZERO EMISSIONS PATHWAY REPORT:

Consolidated Assessment of AFOLU, Energy and Waste Sector Contributions





**GOVERNMENT
OF GHANA**

With kind support from



Environmental Protection Agency (EPA), Ghana



**copenhagen
climate centre**

FOREWORD

Ghana's National Net-Zero Emissions Pathway Report shows how sectors like AFOLU, Energy, and Waste can help achieve net-zero emissions by 2070. Meeting the Paris goals boosts energy security, industries, health, and jobs. Greenhouse gases reached 54.9 MtCO₂e in 2022, potentially rising to 200 MtCO₂e by 2070 without action, over three times current levels. Coordinated efforts could cut emissions to 7–8 MtCO₂e. The choice is ours.

This transformation will be costly. The pathway requires approximately US\$328.5 billion in investment between 2025 and 2070, most of which must be mobilised from private and concessional sources alongside our own resources. Article 6 of the Paris Agreement, and the carbon markets it enables, can raise additional finance and make our mitigation programmes more bankable. We will pursue it with sound governance, monitoring, reporting and verification (MRV), and transparent benefit-sharing.

This pathway is economical. Our trading partners are adding a carbon and land-use cost to imports. The EU's carbon border adjustment begins in January 2026, with deforestation rules starting at year's end. The UK plans similar levies from January 2027. Shipping, aviation, banks, buyers, and insurers will need emissions proof from suppliers. These measures weren't designed for Ghana but affect our exports' market access and pricing. Low-carbon, deforestation-free products will keep market access; others will pay. Decarbonising energy, industry, and land use is vital for competitiveness and climate, protecting sectors that employ many people.

A just transition supports those affected by change through affordable options and retraining for households that rely on charcoal and fuelwood, smallholder farmers, and industry workers. Costs are immediate and local, while benefits are long-term and national. Managing this mismatch is crucial for governments. The report highlights our collaborative approach, balancing sector differences and building trust with evidence such as the Sustainable Development Impact Assessment and our transition pledge. Achieving net-zero requires aligned policies across sectors. Our initial steps include creating an inter-ministerial body and expanding measures within two years.

I thank the Low Carbon Transitions and Environmental Market Unit of the Environmental Protection Authority, UNEP Copenhagen Climate Centre (UNEP-CCC), and the Danish Government through its Foreign Affairs Ministry for their support. This pathway now needs finance, partnership, and follow-through. I invite partners to join us in action.

Prof. Nana Ama Browne Klutse

(Ag. Chief Executive Officer- Environmental Protection Authority)





ACKNOWLEDGEMENTS

The preparation of Ghana's Net-Zero Pathways (NZPs) is both timely and strategic, coming at a point when the country is actively defining how to design and implement a Long-Term Low Emission Development Strategy (LT-LEDS) in line with Article 4.19 of the Paris Agreement. This report will serve as a technical foundation for that strategy. It consolidates the independent sector assessments for Agriculture, Forestry and Other Land Use (AFOLU), Energy, and Waste, together with the cross-cutting Sustainable Development Impact Assessment (SDIA), into a single evidence base to guide Ghana's transition to net zero.

The Low Carbon Transitions and Environmental Markets (LCT/EM) Unit of Ghana's Environmental Protection Agency (EPA) coordinated the preparation of this report on behalf of UNEP-CCC, under the programme "Developing Net-Zero Pathways and Roadmap for Selected Technologies for Ghana," funded by the Ministry of Foreign Affairs of Denmark.

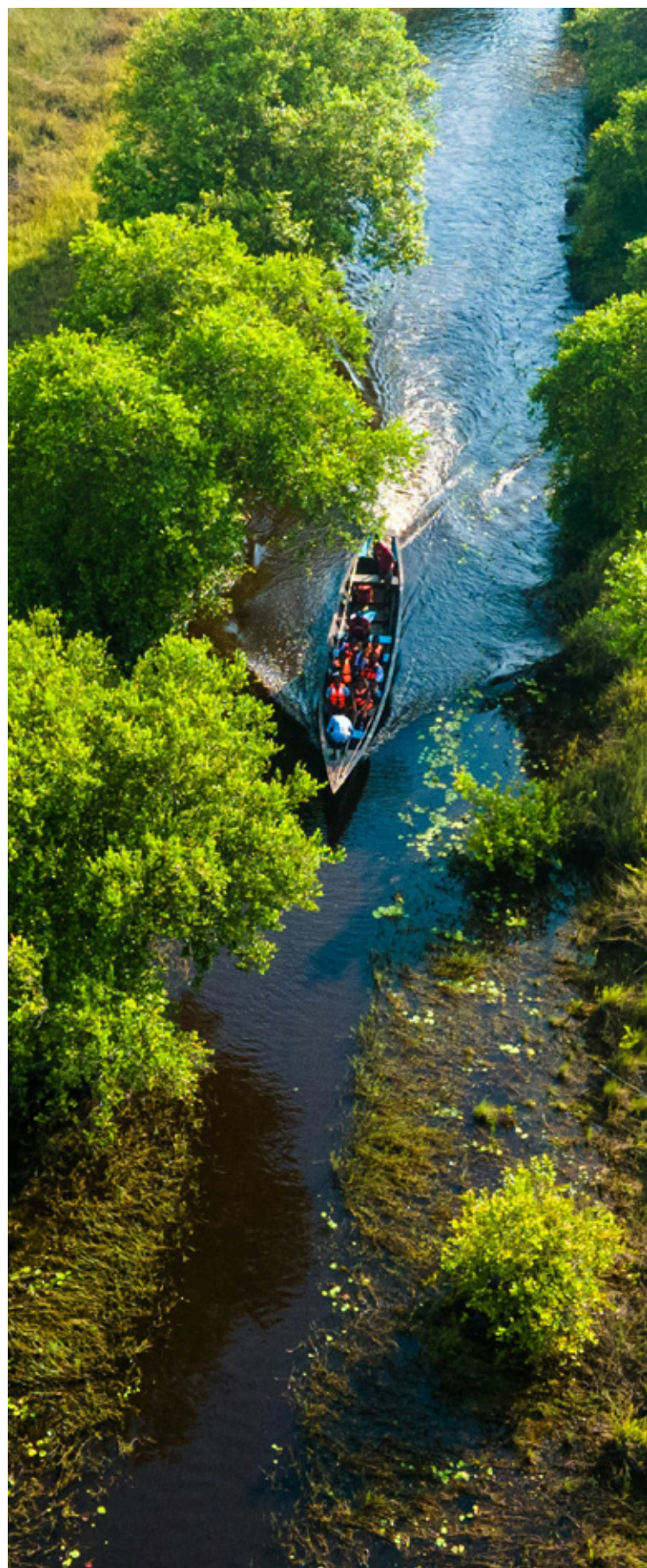
The EPA gratefully acknowledges UNEP-CCC for the technical guidance and financial support that made this work possible, and the Government of Denmark for its generous funding through the Ministry of Foreign Affairs. The Agency extends its sincere appreciation to the national sector experts and consultants whose analytical rigour and commitment shaped the assessments presented here, and to the ministries, departments, agencies, academia, civil society organisations, and private sector partners whose inputs during the consultation and validation processes substantially strengthened the report.

The EPA trusts that this report will inform national policy dialogue and support Ghana's long-term ambition of achieving net-zero emissions.

Table of Contents

Foreword	04		
Acknowledgements	05		
List of Figures and Tables	08		
Abbreviations and Acronyms	09		
Executive Summary	10		
ES.1 Overview and key findings	10		
ES.2 Ghana's 2022 emission profile	10		
ES.3 Future emission scenarios by 2070	10		
ES.3.1 Business-as-usual scenario	10		
ES.3.2 Net-zero emission pathway	10		
ES.4 The investment requirements	11		
ES.5 The carbon finance and Article 6 opportunity	12		
ES.6 Sector synthesis	12		
ES.7 Development and just-transition implications	13		
ES.8 Key recommendations	13		
Chapter 1: Introduction and National Context	14		
1.1 Background	14		
1.2 Ghana's climate-policy context	15		
1.3 Why focus on the AFOLU, energy, and waste sectors	15		
1.4 Purpose, scope, and the integration challenge	15		
Chapter 2: Methodological Framework	16		
2.1 Source reports and their methods	17		
2.2 Consolidated baseline emissions	17		
2.3 Harmonised scenario architecture	17		
2.4 Emissions accounting and integration approach	18		
Chapter 3: National Baseline Emissions Profile	19		
3.1 The 2022 national baseline	20		
3.2 Dominant sources within each sector	21		
3.2.1 Energy	21		
		3.2.2 AFOLU	21
		3.2.3 Waste	21
		3.3 The business-as-usual trajectory to 2070	21
		Chapter 4: AFOLU Net-Zero Pathway	22
		4.1 Scenario pathways	
		4.2 Mitigation portfolio, cost, and the residual	23
		4.3 Investment, carbon finance, and co-benefits	24
		Chapter 5: Energy Sector Net-Zero Pathway	25
		5.1 The transformation logic	26
		5.2 The marginal abatement cost finding	26
		5.3 Investment and financing	27
		Chapter 6: Waste Sector Net-Zero Pathway	28
		6.1 Scenario results	29
		6.2 Measures, cost, and investment	29
		Chapter 7: Integrated National Net-Zero Pathway	30
		7.1 Net-zero emission trajectory	31
		7.2 National mitigation wedges	31
		7.3 The national residual and how it is closed	32
		7.4 Sequencing the national transition	32
		Chapter 8: Investment and Climate Finance Needs	33
		8.1 Consolidated investment requirement	34
		8.2 Phasing the investment	35
		8.3 Financing structure and the catalytic gap	35
		8.4 Carbon finance and Article 6	36
		8.5 Financing instruments and bankable packages	36
		Chapter 9: Policy and Regulatory Requirements	37
		9.1 National climate governance and coordination	38

9.2	Lead institutions by workstream	38
9.3	Priority legal and regulatory reforms	39
9.3.1	Carbon market	39
9.3.2	Energy	39
9.3.3	Land use	39
9.3.4	Waste management	39
Chapter 10: MRV, Data Systems, and Transparency		40
10.1	The transparency backbone	41
10.2	Priority data improvements	41
Chapter 11: Socioeconomic, Just Transition, and Sustainable Development Impacts		42
11.1	Development co-benefits	43
11.2	Gender-responsive transition	43
11.3	Just transition and economic diversification	43
Chapter 12: Risks, Barriers, and Mitigation Measures		45
Chapter 13: Implementation Roadmap		47
Chapter 14: Conclusions and Recommendations		49
14.1	Recommendations	50
Annex 1: Harmonised Assumptions		51
Annex 2: Sector Mitigation Measures		51
Annex 3: Investment and Finance Summary		52
Annex 4: MRV Indicator Framework		52
Annex 5: Priority Project Pipeline		53



List of Figures and Tables

Figures

Figure 1. Integrated three-sector net-zero pathway, 2022–2070. The gap between BAU and net zero represents the effects of the national mitigation action beyond the NDCs; the residual in 2070 is the contribution required from removals and other sectors. The energy component of the NDC line is a harmonised planning estimate interpolated between the energy sector’s modelled reference and net-zero scenarios.	11
Figure 2. Ghana national GHG emissions by sector, 2022 (incl. LULUCF).	20
Figure 3. Sectoral net-zero pathways, 2022–2070, by sector. The energy pathway shown for the NDC scenario is a harmonised planning estimate interpolated between the energy sector’s modelled Reference and Net-Zero scenarios.	31
Figure 4. National mitigation wedges from business-as-usual to net zero. The residual net-emissions band is the contribution required from removals and out-of-scope sectors.	32
Figure 5. Net-zero investment required by sector, 2025–2070.	34
Figure 6. Article 6 and carbon-finance opportunity by sector (indicative). All three opportunities depend on shared MRV and registry infrastructure.	36

Tables

Table ES-1 Summarises the three-sector assessments on a common set of dimensions	12
Table 2.1. Source reports consolidated in this assessment	17
Table 2.2. Harmonised scenario architecture	18
Table 3.1. Harmonised 2022 national emissions baseline	20
Table 3.2. Integrated national emissions by scenario across three sectors (MtCO ₂ e/year)	21
Table 4.1. Net AFOLU emissions by scenario	23
Table 4.2. AFOLU highest-priority measures by composite priority index	24
Table 5.1. Energy MACC priority ranking	26
Table 6.1. Waste sector emissions by scenario (ktCO ₂ e/year)	29
Table 8.1. Consolidated investment requirement by sector	34
Figure 5. Net-zero investment required by sector, 2025–2070.	34
Table 8.2. Consolidated investment by sector and phase	35
Table 8.3. Financing structure	35
Table 9.1. Consolidated responsibility map across the three sectors	38
Table 10.1. MRV and data readiness priorities	41
Table 11.1. Synthesised overview of findings from the SDIA gender and just-transition matrices	44
Table 12.1. Consolidated national risk matrix across the three sectors	46
Table A7.1. Proposed additional visuals: purpose, type, data, and placement	54

Abbreviations and Acronyms

Acronym	Definition
AFOLU	Agriculture, Forestry, and Other Land Use
ALU	Agriculture and Land Use (GHG software tool)
AR5	IPCC Fifth Assessment Report
AWD	Alternate Wetting and Drying (rice cultivation)
BAU	Business as Usual
BTR	Biennial Transparency Report
BTR1	Ghana's First Biennial Transparency Report
CMO	Carbon Market Office
DFI	Development Finance Institution
EPA	Environmental Protection Authority
EPR	Extended Producer Responsibility
ESCO	Energy Service Company
ETF	Enhanced Transparency Framework
ETIP	Energy Transition and Investment Plan
EV	Electric Vehicle
FPIC	Free, Prior, and Informed Consent
FREL	Forest Reference Emission Level
GACMO	Greenhouse Gas Abatement Cost Model
GCF	Green Climate Fund
GCR	Ghana Carbon Registry
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GWP	Global Warming Potential
HVAC	Heating, Ventilation, and Air-Conditioning
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
ITMO	Internationally Transferred Mitigation Outcome
KPI	Key Performance Indicator
LEAP	Low Emissions Analysis Platform
LPG	Liquefied Petroleum Gas
LTS	Long-Term (Low-Emission Development) Strategy
LULUCF	Land Use, Land-Use Change, and Forestry
MAC	Marginal Abatement Cost
MACC	Marginal Abatement Cost Curve
MDB	Multilateral Development Bank
MMDA	Metropolitan, Municipal, and District Assembly
MRV	Measurement, Reporting and Verification
MTNDPF	Medium-Term National Development Policy Framework
MoFA	Ministry of Food and Agriculture
MtCO ₂ e	Million tonnes of carbon dioxide equivalent
NDC	Nationally Determined Contribution
NEMO	National Energy Modelling tool
NEXT	Non-CO ₂ Emissions Xcel Tool (AFOLU modelling)
NID	National Inventory Document
NID1	Ghana's First National Inventory Document
NZT	Net Zero by 2070 (Transformation) scenario
PAM	Policy and Measure
RACI	Responsible, Accountable, Consulted, Informed (responsibility matrix)
REDD+	Reducing Emissions from Deforestation and Forest Degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks
SDG	Sustainable Development Goal
SDIA	Sustainable Development Impact Assessment
UNEP-CCC	UNEP Copenhagen Climate Centre

Executive Summary

ES.1

Overview and key findings

Ghana aims to achieve net-zero greenhouse gas emissions by 2070. This report combines sector assessments for Agriculture, Forestry, and Other Land Use, Energy, and Waste into a single national pathway. It uses the SDIA as the evidence base for gender, just transition, SDG impacts, and safeguards. Prepared by Ghana's EPA for UNEP-CCC

under the 'Developing Net-Zero Pathways' programme, it aligns sector baselines, scenarios, and assumptions, highlights discrepancies, and presents one national pathway, investment framework, carbon-finance approach, and implementation plan.

ES.2

Ghana's 2022 emission profile

In 2022, Ghana's greenhouse gas emissions were approximately 54.9 MtCO₂e, including LULUCF. Energy contributed 24.8 MtCO₂e (45.1%), AFOLU 18.4 MtCO₂e (33.6%), and Waste 9.8 MtCO₂e (17.8%), together

accounting for 96.5%. Industrial processes and non-energy fugitive sources, totalling 3.5%, are outside the scope of this report; consequently it is not representative of a full net-zero strategy.

ES.3

Future emission scenarios by 2070

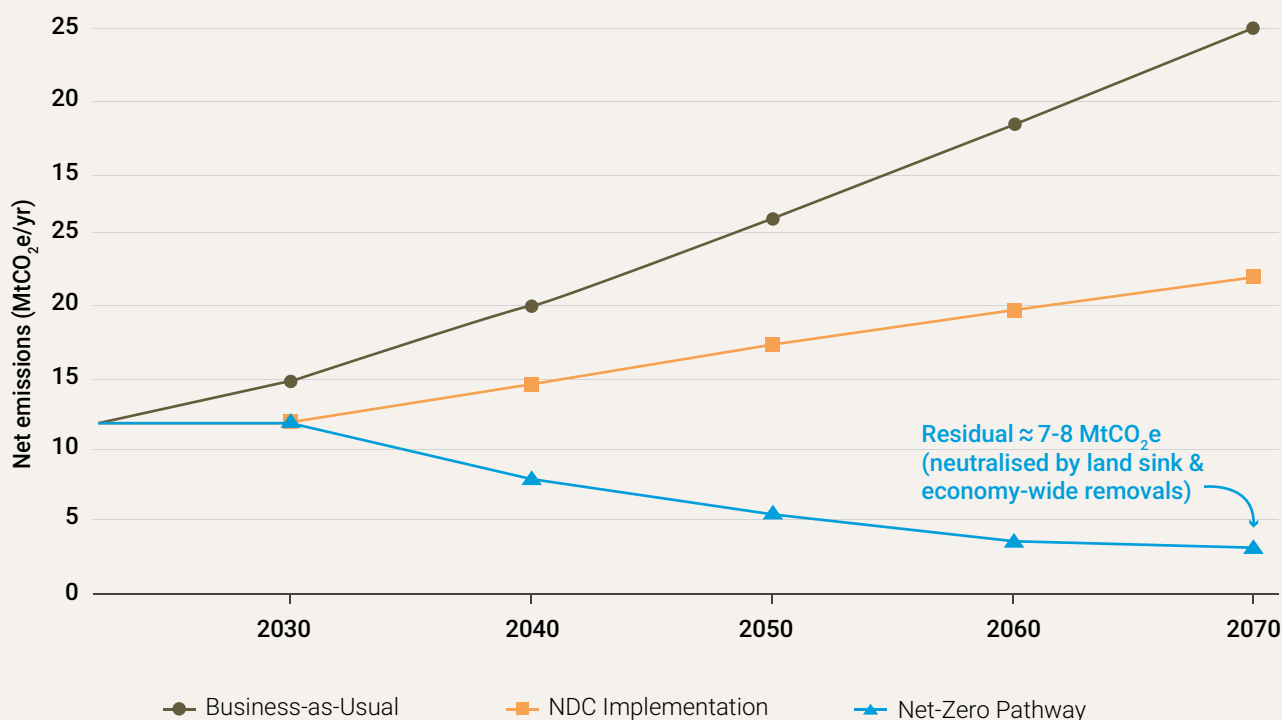
ES.3.1 Business-as-usual scenario

Unaddressed, emissions from these sectors are expected to rise from approximately 53 MtCO₂e in 2022 to nearly 200 MtCO₂e by 2070, driven by transport fuel demand, electricity use, urban growth, waste, and land-use change. The 2070 BAU total comprises AFOLU (39.4 MtCO₂e), Waste (66.33 MtCO₂e), and Energy (94.97 MtCO₂e). The NDC pathway may slow, but not reverse the growth in emissions. The emissions under the NDC pathway are projected to reach approximately 106 MtCO₂e by 2070. Emissions are projected to reach approximately 106.0 MtCO₂e in 2070. Notably, the energy component of the projected NDC emission trends was not independently modelled; it was obtained by interpolating between the reference and net-zero scenarios in the energy model.

ES.3.2 Net-zero emission pathway

The net-zero pathway causes significant economic shifts in Ghana. By 2070, emissions are projected to fall to 7–8 MtCO₂e, with waste emissions ending by 2060 and energy emissions near zero. AFOLU measures offset some emissions, but not entirely, as agricultural emissions persist. The main sectors could nearly reach net zero, leaving a residual of 6–8 MtCO₂e from hard-to-abate non-CO₂ emissions and other sources. Addressing this requires broad measures such as IPPU mitigation and permanent carbon removal rather than sector-specific actions. Planning for a manageable residual, not relying solely on land sinks, offers a realistic long-term strategy.

Figure 1. Integrated three-sector net-zero pathway, 2022–2070. The gap between BAU and net zero represents the effects of the national mitigation action beyond the NDCs; the residual in 2070 is the contribution required from removals and other sectors. The energy component of the NDC line is a harmonised planning estimate interpolated between the energy sector’s modelled reference and net-zero scenarios.



By 2070, energy is expected to remain the primary mitigation source due to persistently high emissions under business-as-usual scenarios. Key strategies include electrification, increased use of renewable energy, transportation shifts, efficiency improvements, and fuel switching. Waste management offers the greatest potential for savings, preventing a sevenfold increase through wastewater treatment, diversion of organic waste, landfill gas recovery, fostering a circular economy, and closing open dumps.

The AFOLU sector combines source reduction with carbon removal methods, including avoided deforestation, forest restoration, agroforestry, improved rice cultivation, soil and nutrient management, and livestock improvements. This pathway nearly reaches net-zero emissions across three sectors, with approximately 7.7 MtCO₂e of residual emissions in 2070 and approximately 6.2 MtCO₂e from AFOLU, partly offset by a 6.1 MtCO₂e land sink. An extra 1.5 MtCO₂e remains as residual energy-related emissions.

ES.4

The investment requirements

Achieving the net-zero pathway across three sectors requires approximately US\$328.5 billion from 2025 to 2070, with higher costs associated with IPPU and residual emissions. Energy investments amount to US\$317.6 billion (96.7%), primarily for transport electrification, freight changes, renewables, grid development, and storage. The waste sector needs US\$6.7 billion, while AFOLU requires approximately US\$4.2 billion. Despite smaller capital

requirements, AFOLU and Waste provide early, low-cost benefits. The report estimates US\$178.09 billion from private sources, US\$54.52 billion from public finance, US\$74.09 billion from concessional finance, and US\$10.87 billion in grants. Concessional finance and grants total US\$84.95 billion, essential for catalytic mobilisation. Carbon finance enhances project economics but cannot replace core investments or affordability support.

ES.5

The carbon finance and Article 6 opportunity

All three sectors offer monetisable opportunities under Article 6 of the Paris Agreement to enhance bankability and attract private investment. However, carbon revenue cannot replace public, concessional, or private funding. A managed energy crediting portfolio of 250 MtCO₂e could generate US\$3.25 billion at US\$20/tCO₂e, US\$0.81 billion at US\$5/tCO₂e, or US\$8.13 billion at US\$50/tCO₂e. The AFOLU pipeline could grow from

17 MtCO₂e/year of ITMOs by 2030 to 68 MtCO₂e/year by 2050, earning over US\$4.2 billion. In Waste, twelve measures qualify under Article 6.2, building on Ghana's ITMO deal with Switzerland. Carbon revenue could rise from US\$60 million to over US\$1 billion annually, depending on a functional Ghana Carbon Registry, approval, governance, benefit-sharing, MRV, and clear distinctions among ITMOs, voluntary credits, and NDC reductions.

ES.6

Sector synthesis

Table ES-1 Summarises the three-sector assessments on a common set of dimensions

Table ES-1. Sector synthesis information

Parameter	AFOLU	Energy	Waste
2022 emissions	18.4 MtCO ₂ e (33.6%)	24.8 MtCO ₂ e (45.1%)	9.8 MtCO ₂ e (17.8%)
BAU 2070	39.4 MtCO ₂ e (+114%)	~95 MtCO ₂ e	66.3 MtCO ₂ e (~7x)
Net-zero outcome	6.2 Mt residual by 2070	Near-zero by 2070	Zero by 2060
Dominant source	Enteric fermentation, managed soils, deforestation	Transport, electricity	Wastewater, solid waste
Cost	US\$5.80/tCO ₂ e average marginal abatement cost	Mostly negative-cost measures	Many measures below US\$5/tCO ₂ e
Investment, 2025/26–2070	US\$4.2 billion	US\$317.6 billion	US\$6.7 billion
Lead institutions	Forestry Commission, MoFA, COCOBOD, EPA	Ministry of Energy, Energy Commission, utilities	MMDAs, MLGCRA, EPA
Priority early action	REDD+, cocoa agroforestry, AWD rice, MRV	Efficiency, clean cooking, LED lighting, freight rail	Composting, landfill-gas capture, dump closure, EPR

Development and just-transition implications

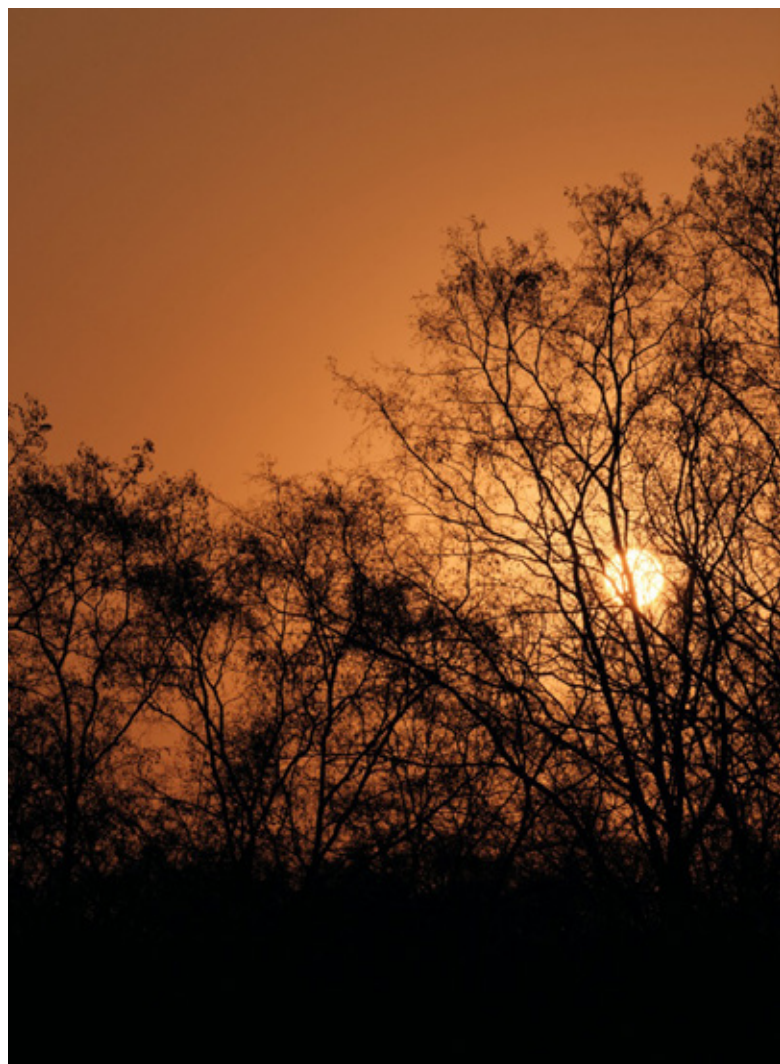
The transition can improve health, energy access, sanitation, food security, ecosystem health, productivity, and economic diversity. The most significant benefits occur when interventions directly reach households and communities, such as clean-cooking solutions, efficient appliances, public transit, sanitation, waste management, mini-grids,

climate-smart agriculture, agroforestry, and forest restoration. However, these benefits are not automatic. Factors such as affordability, skills development, worker transition, land rights, FPIC, occupational safety, local procurement, women's access to finance, and transparent benefit-sharing influence who benefits and who bears the costs.

Key recommendations

The first implementation period should concentrate on enabling systems and no-regret measures while preparing the capital-intensive programmes required after 2030. The actions should begin within the next two years:

- Create an inter-ministerial net-zero delivery implementation mechanism with annual budgets, milestones, and public reporting.
- Complete the integrated MRV architecture, wastewater inventory improvement, LULUCF FREL reconciliation, and granular energy data programme.
- Launch the negative-cost energy portfolio: efficient lighting, cooling, appliances, clean cooking, and selected transport efficiency measures.
- Scale composting, landfill gas capture, open-dump closure, EPR, and the National Waste Information System.
- Scale AWD rice, REDD+, cocoa agroforestry, and forest landscape restoration with survival-rate MRV and benefit-sharing.
- Establish a national transition-finance programme focused on the US\$84.95 billion catalytic energy requirement and blend AFOLU and waste finance.
- Prepare bankable renewable power, grid, storage, electric mobility, freight rail, and wastewater investment packages.
- Adopt just-transition safeguards covering affordability, informal workers, land tenure, FPIC, grievance mechanisms, gender targets, and local skills.





Chapter 1: Introduction and National Context

1.1

Background

Ghana's pledge to achieve net-zero greenhouse gas emissions by 2070 signifies a major change in its development path. It serves as both a mitigation goal under the Paris Agreement and a chance to boost energy security, modernise industry, enhance rural livelihoods, safeguard public health, and promote social inclusion. Turning this pledge into a credible, well-funded, and practical national strategy demands a unified, economy-wide analytical approach. This report is the first comprehensive step in that framework, focusing on three sectors.

1.2

Ghana's climate-policy context

Ghana's climate strategy combines the long-term 2070 net-zero objective with a nearer-term Nationally Determined Contribution (NDC). The 2021 NDC revision sets an unconditional target of 24.6 MtCO₂e in emissions reductions and a conditional target of 64 MtCO₂e by 2030, both measured against an economy-wide business-as-usual baseline. The 2022 baseline used throughout this report is drawn from the Sixth National Greenhouse Gas Inventory (NID1, December 2024) and Ghana's first Biennial

Transparency Report (BTR1). The Energy Transition and Investment Plan (ETIP) and the National Energy Transition Framework (2022–2070) underpin the energy-sector trajectory; Ghana's REDD+ programme and Forest Reference Emission Level (FREL) underpin the land-sector analysis; and the waste-sector pathway is guided by the National Solid Waste Management Strategy, the Environmental Protection Act, 2025 (Act 1124), and Ghana's commitments under the Global Methane Pledge.

1.3

Why focus on the AFOLU, energy, and waste sectors

The three sectors were selected because they represent both the largest sources of emissions and the largest mitigation opportunities available to Ghana today, together accounting for 96.5% of 2022 national emissions. Each plays a distinct strategic role. Energy is the largest and fastest-growing source of emissions and the primary arena for capital-intensive transformation. AFOLU is a substantial source of

emissions but also Ghana's principal reservoir of low-cost mitigation and carbon dioxide removal, uniquely positioned to become a major net sink rather than a net source. Waste is the third-largest source and the leading contributor to national methane emissions, with mitigation closely tied to public health, sanitation, and circular economy outcomes.

1.4

Purpose, scope, and the integration challenge

This report combines three sector assessments into a unified national net-zero story. The process is complex due to differences in base years (2022 for inventories, 2024 for Energy), scenarios (BAU/NDC/Net Zero vs. Reference/Net-Zero), modelling tools (ALU and NEXT for AFOLU; LEAP, NEMO, GACMO for Energy; IPCC-based Excel for Waste), and target years (2070 for AFOLU and Energy, 2060 for Waste). Chapter 2 details how these differences were reconciled. The scope covers three sectors from 2022–2070, including all direct GHGs using AR5 GWPs, and spans baseline to mitigation pathways, investment needs, financing, institutional arrangements, MRV, safeguards, and implementation.

Ghana's net-zero goal is embedded within its broader development plan, mainly the Medium-Term National Development Policy Framework (MTNDPF) for 2026–2029,

titled "Resetting Ghana Agenda: Creating Jobs, Ensuring Accountability and Promoting Shared Prosperity." This builds on Agenda for Jobs II (2022–2025) with the goal of creating a fair, inclusive, and prosperous Ghana through production-led growth, jobs, and social justice. Developed by the National Development Planning Commission to comply with the 1992 Constitution, the MTNDPF guides planning and budgeting at all government levels, which must align with this report's measures. Agencies such as the Ministry of Energy and Green Transition, the Ministry of Food and Agriculture, the Forestry Commission, and MMDAs develop activities through this cycle, not just climate-specific tools. Integrating the net-zero strategy into future MTNDPF cycles, rather than as a separate project, provides a practical path from strategy to budget.



Chapter 2: Methodological Framework

This chapter explains how the three sector assessments were reviewed, aligned, and consolidated into a single national framework. The guiding principle is transparency. Every reconciliation is stated, official inventory data are kept distinct from projections, and the integration deliberately avoids implying a precision that the underlying sector data cannot support. The consolidation used the official 2022 national inventory as the common point of reference for cross-sector comparisons, retained each sector's model structure for forward projections, and mapped sector scenarios into BAU, NDC implementation, and transformation pathways. It then reconciled units, boundary statements, GWP conventions, target years, reported costs, and implementation periods. Where the source reports did not provide comparable results, the consolidated report records an interpolation or a data gap rather than presenting false precision.

2.1

Source reports and their methods

The Sustainable Development Impact Assessment (SDIA) is the principal cross-cutting evidence source for just transition, gender, and SDG impacts, underpinning Chapter 11. Table 2.1 summarises the four source reports.

Table 2.1. Source reports consolidated in this assessment

Sector report	Base year/ horizon	Tools	Scenarios	Net-zero target
AFOLU	2022 / 2070	ALU and NEXT (formula-driven Excel)	BAU, NDC, Net Zero (NZT)	2070 (with residual)
Energy (Ministry of Energy)	2024 / 2070	LEAP, NEMO, GACMO	Reference, Net Zero	2070
Waste (EPA)	2022 / 2070	Excel emissions model (IPCC methods)	BAU, NDC, Net Zero	2060
SDIA (cross-cutting)	Policy framework	SDIA matrix (environmental/social/economic dimensions)	NDC 2.0, NDC 3.0/ETIP, Accelerated	—

2.2

Consolidated baseline emissions

All three sectors are based on Ghana's 2022 greenhouse gas inventory (NID1/BTR1) and use AR5 global warming potentials ($\text{CH}_4 = 27.9$; $\text{N}_2\text{O} = 273$). This clarifies the main baseline discrepancy: the energy report's LEAP model estimates 35.8 MtCO₂e for 2024 (including methane from biomass combustion), whereas the official inventory reports

24.8 MtCO₂e for the energy sector, treating biomass CO₂ as carbon neutral. Table 2.1 and the harmonised baseline in Chapter 3 use the 2022 inventory figures for cross-sector comparison; energy-sector modelling continues to reference LEAP where noted. This distinction is consistently maintained throughout the report.

2.3

Harmonised scenario architecture

The three sector reports use different scenarios and align them into a common three-scenario structure: Business-as-Usual (BAU), NDC, and net-zero pathways (NZP), plus explicit residual management. Table 2.2 sets out the harmonised architecture.

Note that the energy report itself models only the reference and net-zero scenarios, so the national NDC interpolates a middle-energy pathway that should be read as a harmonised planning estimate rather than a directly modelled result.

Table 2.2. Harmonised scenario architecture

Scenario	Definition	AFOLU	Energy	Waste
BAU	Historical trends continue; no strengthened mitigation	BAU	Reference	BAU
NDC	Full delivery of NDC-aligned measures	NDC	Reference and partial	NDC
NZP	Transformational decarbonisation to the net-zero target	Net Zero (NZE)	Net Zero	Net Zero
Residual Management	Hard-to-abate residual neutralised economy-wide	~6.2 Mt residual	Small residual	Zero by 2060

2.4

Emissions accounting and integration approach

- **Accounting basis:** all values in MtCO₂e (or ktCO₂e) using AR5 global warming potentials, consistent with BTR1 and the Common Reporting Tables. Where a sector report used different GWP assumptions, values were converted to AR5.
- **Removals and sinks:** gross emission reductions are reported separately from carbon removals. The AFOLU net sink, including forest restoration, afforestation, cocoa agroforestry, and harvested-wood products, is the only modelled removals pool in this report. Emissions from energy and waste are treated as gross-reduction sectors only.
- **Double counting:** because the three sectors correspond to mutually exclusive IPCC categories (AFOLU = 3A–3D; Energy = 1A/1B; Waste = 5A–5D), there is no inter-sector overlap to net out. Energy used by agricultural machinery and agro-processing is counted under Energy, not AFOLU, consistent with standard inventory practice.
- **Mitigation potential versus investment need:** these are kept strictly distinct. Abatement is expressed in MtCO₂e/year; investment in US\$; the two are never combined into a single figure.
- **Uncertainty:** each sector applies its own robustness analysis. AFOLU a 10,000-draw Monte Carlo simulation; Waste a 16-parameter sensitivity analysis; Energy scenario and EV-cost sensitivity testing. The national residual finding is robust across all three.

An aerial photograph of a tropical beach. In the foreground, several large, round, grey beach umbrellas are open on the white sand. People are scattered across the beach, some sitting and some standing. A small boat is anchored in the shallow, clear water near the shore. The water transitions from a light green near the beach to a darker green further out. The overall scene is peaceful and scenic.

Chapter 3: National Baseline Emissions Profile

This chapter provides the empirical basis for the national pathway, detailing Ghana's 2022 emissions, the significance of each sector within the scope, the main sources in each sector, and the projected business-as-usual trajectory to 2070 that the net-zero strategy aims to reverse.

3.1

The 2022 national baseline

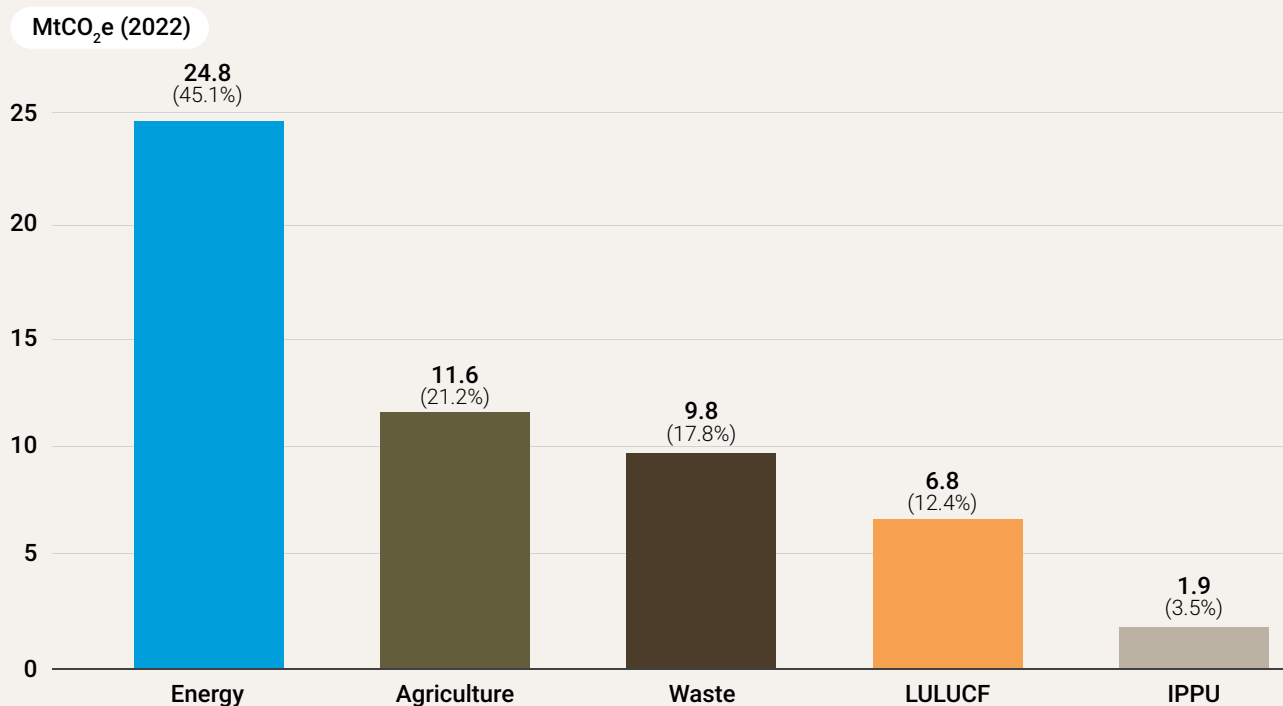
In 2022, Ghana's total national greenhouse gas emissions were approximately 54.9 MtCO₂e, including LULUCF (47.8 MtCO₂e excluding LULUCF). The three sectors covered by this report dominate that profile (Table 3.1 and Figure 2).

Table 3.1. Harmonised 2022 national emissions baseline

Sector	2022 emissions (MtCO ₂ e)	Share of national total	In scope here
Energy (1A/1B)	24.76	45.1%	Yes
Agriculture (3A/3C)	11.63	21.2%	Yes (AFOLU)
Waste (5A–5D)	9.77	17.8%	Yes
LULUCF (3B/3D)	6.79	12.4%	Yes (AFOLU)
IPPU (2)	1.93	3.5%	No
National total (incl. LULUCF)	54.88	100%	96.5% in scope

Source: AFOLU (Agriculture plus LULUCF) equals 18.4 MtCO₂e, or 33.6% of the national total.

Figure 2. Ghana national GHG emissions by sector, 2022 (incl. LULUCF).



3.2

Dominant sources within each sector

3.2.1 Energy

Transport is the largest and fastest-growing energy source, rising from 6.1 MtCO₂e (29.7% of energy emissions) in 2010 to 12.8 MtCO₂e (35.8%) in 2024, driven by the expansion of the vehicle fleet from roughly 511,000 vehicles in 2000 to approximately 3.2 million in 2024 and near-total reliance on petrol and diesel. Electricity generation is the second-largest source, with emissions closely tracking thermal generation whenever hydropower output is constrained. Industry accounted for approximately 16% of energy emissions in 2024.

3.2.2 AFOLU

Agriculture contributes 11.6 MtCO₂e, dominated by enteric fermentation and manure management (5.24 MtCO₂e), with the remaining 6.35 MtCO₂e split across managed-soil

nitrous oxide, methane from rice cultivation and savanna burning. The land sector's net contribution is 6.8 MtCO₂e, the outcome of two large and uncertain gross flows that broadly offset one another: emissions from converting forest to cropland and grassland, against carbon removals in standing forest and a small sink from harvested wood products.

3.2.3 Waste

Wastewater treatment and discharge (5,099.5 ktCO₂e, 52.2% of the sector) and solid waste disposal (3,384.5 ktCO₂e, 34.6%) together account for 86.8% of waste-sector emissions. Methane makes up 84.4% of waste emissions, making waste the largest single source of national methane – 44.8% of Ghana's total methane inventory – and a priority sector under the Global Methane Pledge.

3.3

The business-as-usual trajectory to 2070

Without enhanced mitigation, combined emissions from the three sectors are projected to rise from approximately 53 MtCO₂e in 2022 to around 200 MtCO₂e by 2070. AFOLU emissions more than double to 39.4 MtCO₂e (+114%); Waste emissions grow nearly sevenfold to 66.3 MtCO₂e; and Energy, already the largest sector, expands the most in absolute terms on the back of rising transport,

electricity, and gas demand. Common drivers include population growth to an estimated 67.3 million by 2070, rising urbanisation (an estimated 84.8% urban by 2070), rising incomes (GDP per capita of roughly US\$12,800 by 2070) and the slow turnover of long-lived, carbon-intensive capital stock. Table 3.2 sets out the integrated national trajectory by scenario.

Table 3.2. Integrated national emissions by scenario across three sectors (MtCO₂e/year)

Scenario	2022	2030	2040	2050	2070
Business-as-Usual	53.0	69.9	96.5	129.8	200.7
NDC Implementation	53.0	54.2	68.0	83.0	106.0
Net-Zero Pathway	53.0	54.6	32.5	18.8	~7.7

Note: The Energy component of the NDC Implementation row is a harmonised planning estimate interpolated between the energy sector's modelled reference and net-zero scenarios



Chapter 4: AFOLU Net-Zero Pathway

The land sector plays a crucial role in Ghana's goal of achieving net-zero emissions. In 2022, it contributed 33.6% of the country's total emissions. At the same time, it represents Ghana's largest source of affordable mitigation options and is the only major sector with potential for significant carbon dioxide removal, capable of shifting from a net emitter to a major net sink.

4.1

Scenario pathways

Three scenarios were modelled for 2070. Under Business-as-Usual, net AFOLU emissions double to 39.4 MtCO₂e (+114%), driven by expanding livestock, cropland, rice systems, and deforestation. NDC measures still leave 26.6 MtCO₂e in 2070 (+45% vs 2022), indicating that current ambition cannot fully decarbonise the land sector. The Net-zero pathway, which requires the near elimination of gross

deforestation by 2040, forest restoration, cocoa agroforestry, and agricultural transformation, projects emissions to drop to 6.2 MtCO₂e, a 66% reduction from 2022 and an 84% reduction from BAU 2070. A Monte Carlo analysis found that no outcomes reach net zero within AFOLU alone (0% success), indicating this residual is structural.

Table 4.1. Net AFOLU emissions by scenario

Scenario	2030 (MtCO ₂ e)	2070 (MtCO ₂ e)	Change vs. 2022	Change vs. BAU 2070
Business-as-Usual	22.3	39.4	+114%	—
NDC Implementation	17.3	26.6	+45%	–33%
Net-Zero by 2070	19.7	6.2	–66%	–84%

4.2

Mitigation portfolio, cost, and the residual

Twenty prioritised measures (PAM-01 to PAM-20) covering areas such as avoided deforestation, forest restoration, agroforestry, transition from tree to crop cultivation, fire and fuelwood management, livestock and manure handling, as well as rice and soil-carbon practices are expected to achieve a reduction of 122.5 MtCO₂e annually by 2070. This represents 67% of the total technical potential of 182.7 MtCO₂e. The average marginal cost for these measures is US\$5.80 per tonne of CO₂e; approximately 35% cost

less than US\$5 per tonne, and 91% cost less than US\$10 per tonne, highlighting significant low-cost, land-based mitigation options. Table 4.2 ranks these measures based on a composite priority index. Strengthening MRV systems is listed first as an enabling measure, not for direct emission reductions but because it ensures accurate accounting, transparent reporting and verification, and maintains the environmental integrity of carbon credits across the entire AFOLU portfolio.

Table 4.2. AFOLU highest-priority measures by composite priority index

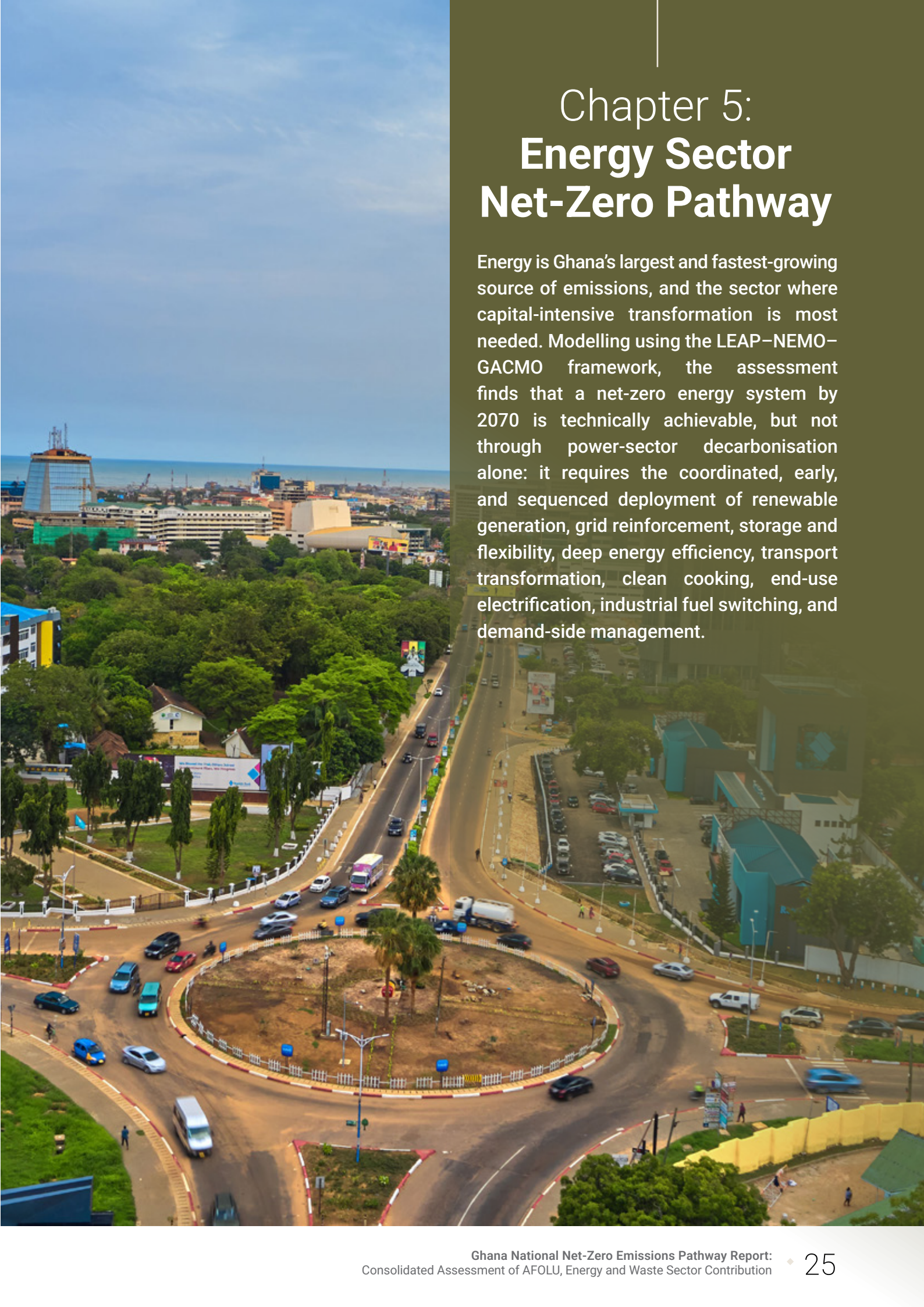
Priority measure	Group	2070 abatement (Mt/yr)	MAC (US\$/t)	Priority index
Cocoa agroforestry transformation	Agroforestry	14.2	5.5	0.90
Forest landscape restoration	Restoration and removals	18.4	8.1	0.88
Alternate wetting and drying (rice)	Rice/soil	4.6	1.8	0.87
REDD+ forest protection	Avoided deforestation	9.5	4.5	0.86
National afforestation/reforestation	Restoration and removals	12.7	6.4	0.85
Improved biomass cookstoves	Fire and fuelwood	2.2	-2.1	0.84

4.3

Investment, carbon finance, and co-benefits



Delivering the net-zero portfolio requires approximately US\$4.2 billion from 2026 to 2070, approximately US\$34 million per MtCO₂e of annual abatement, a competitive figure for land-based mitigation. The largest allocations are forest landscape restoration and removals (US\$1.18 billion), agroforestry and tree-crop transformation (US\$925 million), and rice, nutrient, and soil-carbon management (US\$785 million). At a blended carbon price of US\$5 to US\$20/tCO₂e, cumulative carbon-finance revenue could significantly exceed the required investment; the portfolio could also support an Article 6 ITMO pipeline of approximately 17 MtCO₂e/year by 2030, rising to approximately 68 MtCO₂e/year by 2050. The strongest co-benefits are in livelihoods, food security, and resilience: cocoa agroforestry, REDD+, forest restoration and AWD rice combine substantial low-cost abatement with strong development outcomes, making this portfolio a genuine no-regret investment.



Chapter 5: Energy Sector Net-Zero Pathway

Energy is Ghana's largest and fastest-growing source of emissions, and the sector where capital-intensive transformation is most needed. Modelling using the LEAP–NEMO–GACMO framework, the assessment finds that a net-zero energy system by 2070 is technically achievable, but not through power-sector decarbonisation alone: it requires the coordinated, early, and sequenced deployment of renewable generation, grid reinforcement, storage and flexibility, deep energy efficiency, transport transformation, clean cooking, end-use electrification, industrial fuel switching, and demand-side management.

5.1

The transformation logic

Under the Reference Scenario, emissions rise through 2070 due to ongoing policies and trends. Petroleum remains the main energy source, growing from 55.8% of total consumption in 2024, while natural gas use for power generation nearly sextuples. In the Net-Zero Scenario, the energy system transforms: electricity becomes the dominant final energy carrier, increasing from approximately

2.0 to 29.6 energy units between 2025 and 2070, and solar expands from 0.15% to 35.9% of primary supply. Fossil fuels are phased out after 2055, and traditional biomass use drops to sustainable levels. Near-zero electricity-sector emissions by mid-century facilitate electrification's role in economy-wide emission reductions, with transport and industry approaching near-zero emissions by 2070.

5.2

The marginal abatement cost finding

The main economic insight is that most assessed energy mitigation strategies have a negative net cost, meaning they cut emissions and save money over the evaluation period. This changes the perspective on early transition efforts: the initial set of measures largely funds itself. Table 5.1 lists priority measures based on their marginal abatement costs

on the GACMO curve. While measures with negative costs are financially appealing on their own, the shift to LPG for cooking, which has a positive marginal cost, remains in the portfolio due to its additional benefits: increased access to clean cooking, lower household air pollution risks, and better gender outcomes.

Table 5.1. Energy MACC priority ranking

Mitigation option	MAC (US\$/tCO ₂ e)	Priority
Shift freight transport road → rail	-704.0	P1/P2 infrastructure
Efficient wood stoves	-290.2	P1 no-regret
HVAC efficiency improvement	-287.8	P1 no-regret
LED domestic lighting (LED → CFL)	-224.3	P1 no-regret
LED street lighting	-221.1	P1 no-regret (public)
Efficient residential air conditioners	-166.9	P1 no-regret
Efficient induction stoves	-166.5	P1/P2
Shift internal combustion → plug-in EV	-42.0	P2 infrastructure
LPG replacing wood stoves	+31.0	P3 strategic (health/gender)

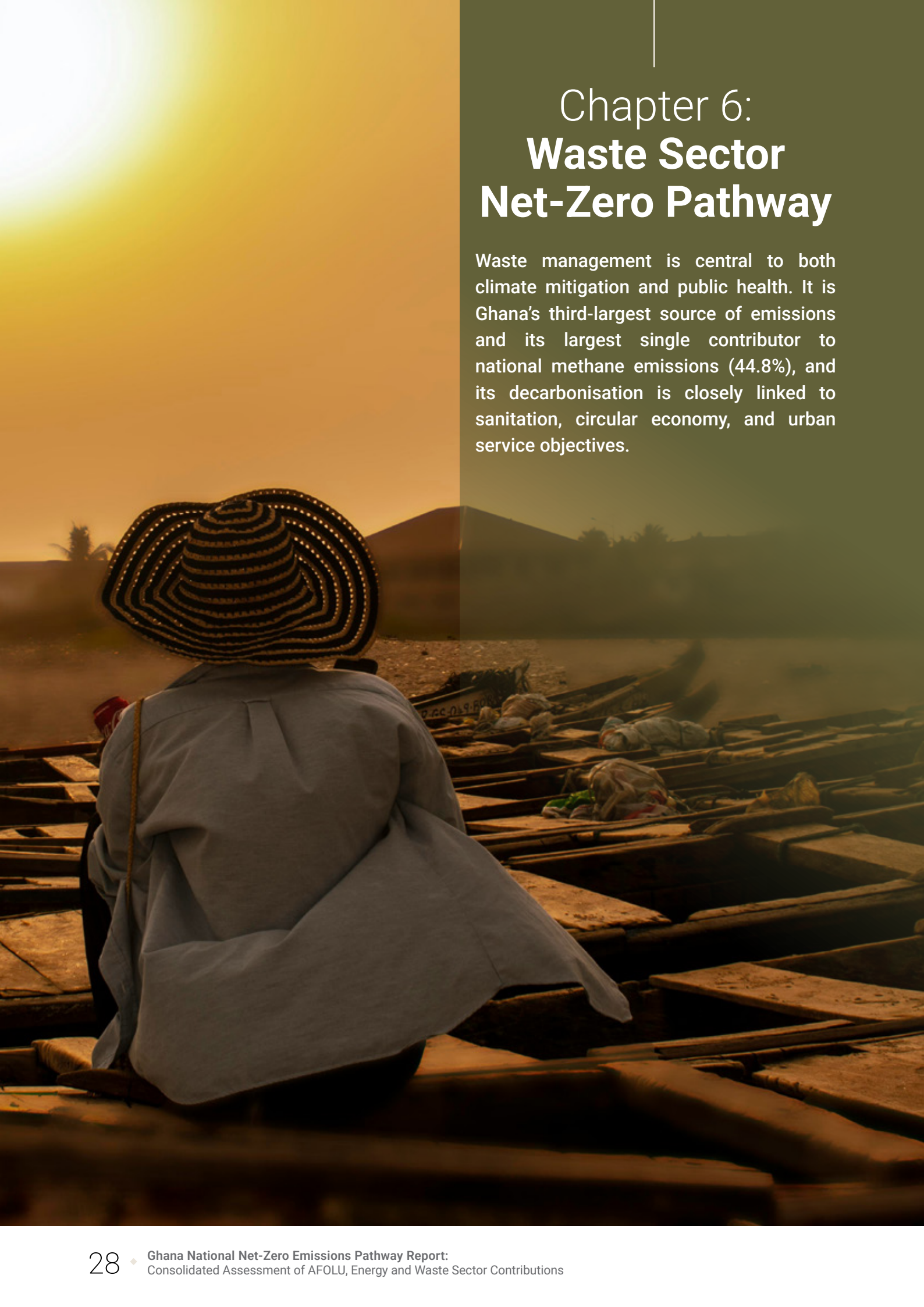
5.3

Investment and financing

The energy transition requires approximately US\$317.56 billion from 2025 to 2070, concentrated in transport (US\$173.72 billion, 54.7%) and electricity (US\$121.42 billion, 38.2%), together with 93% of the total. Industry (US\$13.98 billion), services (US\$4.64 billion), and households (US\$3.80 billion) are smaller in absolute terms but critical for early, cost-effective, and socially beneficial action. Financing draws primarily on private capital (US\$178.09 billion), supported by public finance (US\$54.52 billion), concessional

finance (US\$74.09 billion), and grants (US\$10.87 billion); the combined US\$84.95 billion of concessional and grant finance represents the sector's binding catalytic gap. Investment demand rises sharply over time, from US\$6.69 billion in 2025–2030 to approximately US\$187.79 billion in 2051–2070, reinforcing the case for prioritising no-regret measures now while building the pipeline for later infrastructure. A conservative 250 MtCO₂e crediting portfolio could generate roughly US\$3.25 billion net at US\$20/tCO₂e.





Chapter 6: Waste Sector Net-Zero Pathway

Waste management is central to both climate mitigation and public health. It is Ghana's third-largest source of emissions and its largest single contributor to national methane emissions (44.8%), and its decarbonisation is closely linked to sanitation, circular economy, and urban service objectives.

6.1

Scenario results

Under Business-as-Usual, waste emissions rise nearly sevenfold, from 9,771 ktCO₂e in 2022 to 66,334 ktCO₂e by 2070, with wastewater remaining the largest source and open burning the fastest-growing. Under the NDC scenario, 30 policies and measures deliver a 49.2% reduction relative to BAU by 2030, exceeding Ghana's unconditional 45%

target, but absolute emissions still rise to 27,519 ktCO₂e by 2070 as reductions fail to keep pace with growing waste generation. The Net-zero pathway adds nine further measures from 2030 onward and reaches zero emissions by 2060, with emissions remaining at zero through 2070.

Table 6.1. Waste sector emissions by scenario (ktCO₂e/year)

Scenario	2022	2030	2040	2050	2060	2070
Business-as-Usual	9,771	13,580	20,924	33,076	46,483	66,334
NDC Scenario	8,604*	6,896	9,176	15,161	19,950	27,519
Net-Zero Pathway	8,604*	6,896	4,542	3,775	0	0

* The NDC and Net-zero pathways use the waste-sector model's own 2022 activity-data and emission-factor assumptions, which are marginally lower than the official 2022 national GHG inventory figure used for the Business-as-Usual baseline (Section 1.2; NID1/BTR1), pending the wastewater-inventory reconciliation identified as a priority in Table 10.1. The two 2022 figures reflect a difference in accounting basis, not a change in underlying emissions.

6.2

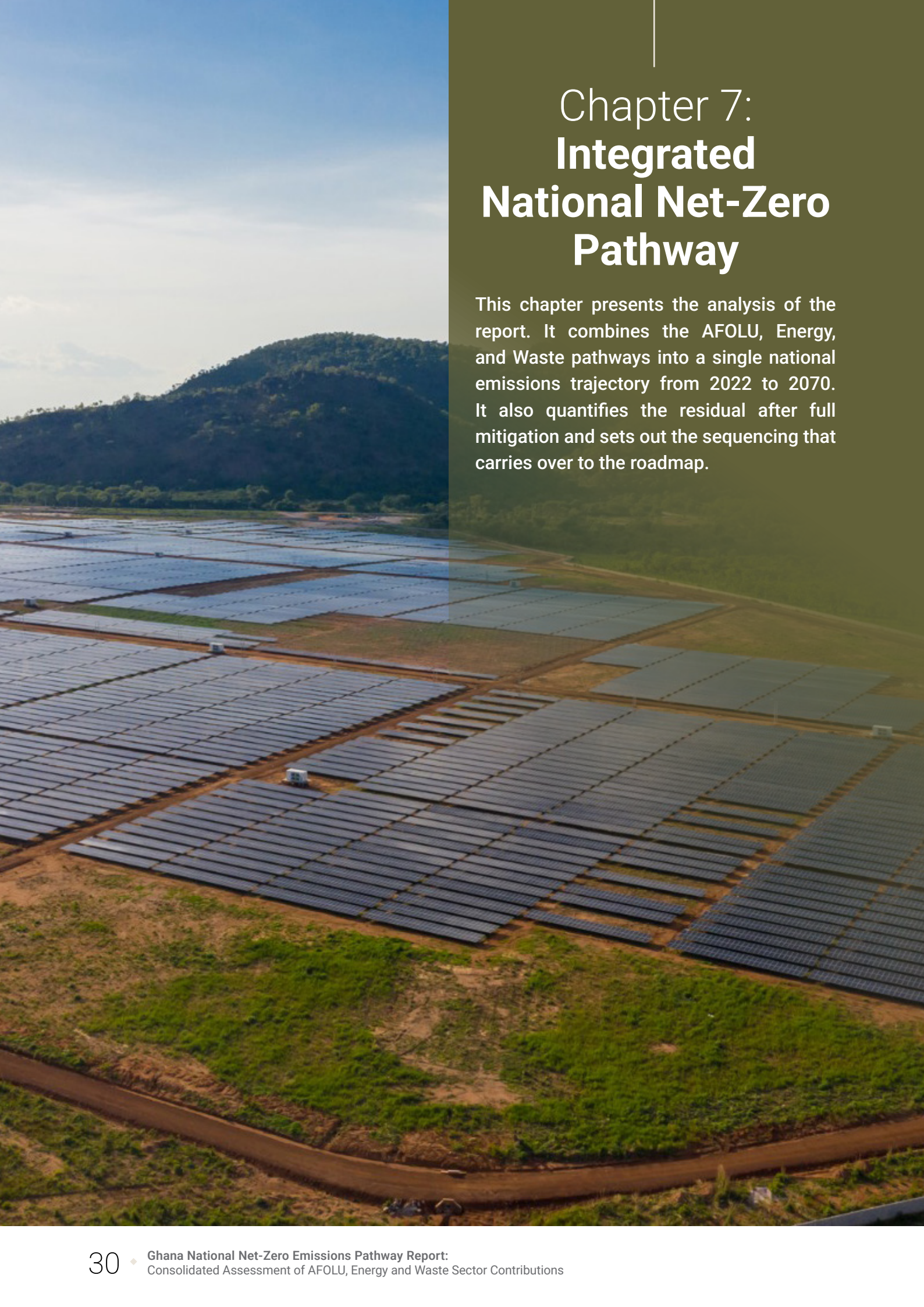
Measures, cost, and investment

The 30-measure portfolio is led by cost-negative and low-cost interventions:

- Extended producer responsibility (–US\$0.74/t)
- Open-burning cessation (US\$2.54/t)
- Zero-waste circular-economy programme (US\$2.81/t)
- Organic landfill ban (US\$4.01/t)
- Landfill-gas capture with power generation (US\$7.02/t)

Measures costing under US\$5 per tonne could deliver roughly 4,870 ktCO₂e annually in peak emissions reductions and should be prioritised. The most effective strategies to

reach net-zero include banning organic landfilling, which accounts for 85% of projected BAU solid-waste emissions, and adopting comprehensive urban wastewater treatment, which accounts for 92% of BAU wastewater emissions. The total investment needed is approximately US\$6.7 billion from 2026 to 2070, nearly evenly split between solid-waste management (US\$3.33 billion) and wastewater treatment (US\$3.37 billion) across five phases. Revenue from carbon credits is expected to increase from around US\$60 million in Phase 1 to over US\$1 billion annually in later stages, with a net surplus in the final decade as carbon prices rise from US\$20/tonne in 2030 to US\$120/tonne by 2070.



Chapter 7: **Integrated National Net-Zero Pathway**

This chapter presents the analysis of the report. It combines the AFOLU, Energy, and Waste pathways into a single national emissions trajectory from 2022 to 2070. It also quantifies the residual after full mitigation and sets out the sequencing that carries over to the roadmap.

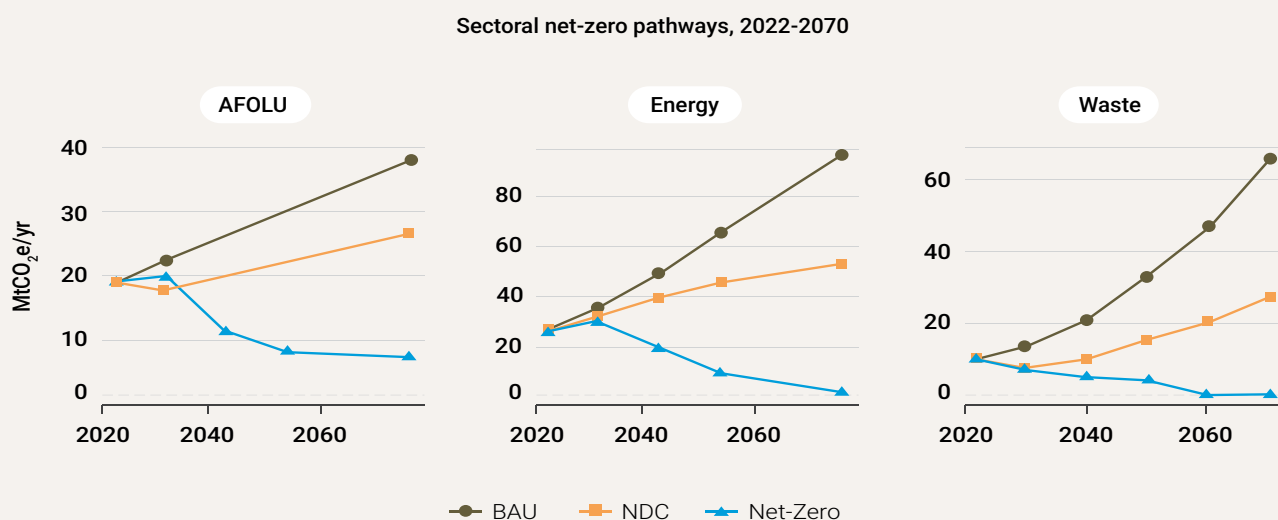
7.1

Net-zero emission trajectory

Across the three sectors, Business-as-Usual emissions increase from approximately 53 MtCO₂e in 2022 to nearly 200 MtCO₂e by 2070. Full NDC implementation leads to emissions of around 106 MtCO₂e, while the net-zero pathway sees combined emissions drop to roughly 7–8 MtCO₂e by 2070. The waste sector reaches net-zero by 2060, energy approaches zero emissions, and AFOLU stabilises as a structural residual, serving as a major carbon sink.

Decarbonisation occurs at different times across sectors: waste achieves net-zero first, in 2060, with the energy sector contributing the largest absolute reductions, mainly after 2040. AFOLU begins early with low-cost abatement and removals but continues non-CO₂ agricultural emissions at a stable baseline. Figure 3 illustrates these sectoral pathways; energy estimates are indicative and harmonised for cross-sector comparability.

Figure 3. Sectoral net-zero pathways, 2022–2070, by sector. The energy pathway shown for the NDC scenario is a harmonised planning estimate interpolated between the energy sector’s modelled Reference and Net-Zero scenarios.



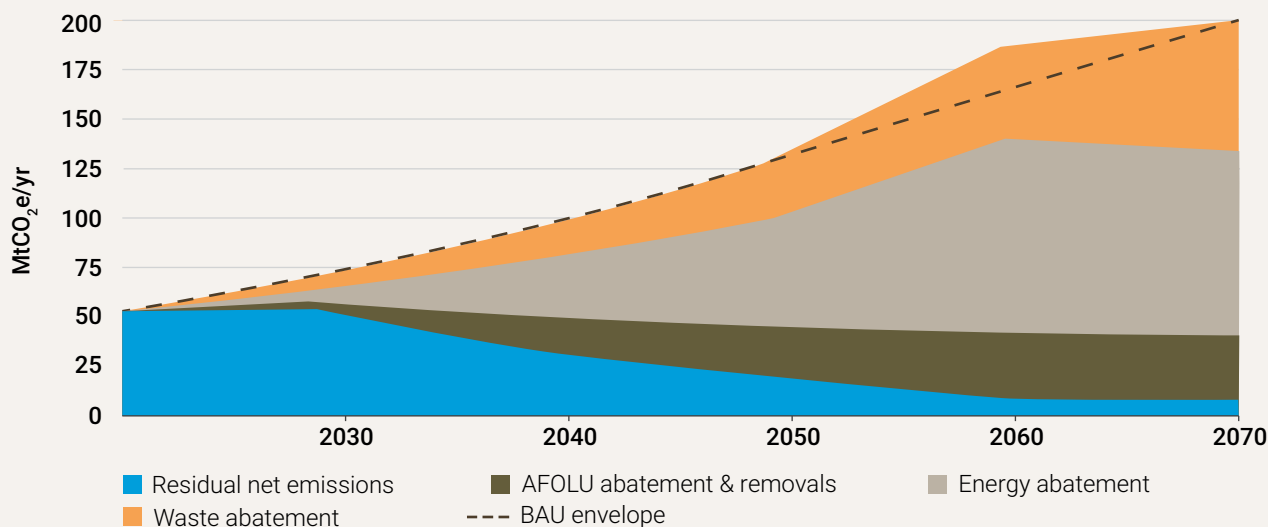
7.2

National mitigation wedges

The effects of mitigation efforts are represented as a series of wedges, each indicating the reduction required from a sector to shift the national trajectory from BAU to net zero. By 2070, the energy wedge is the largest in absolute terms, reflecting the sector’s size. The waste sector wedge exhibits the greatest proportional reduction, decreasing from nearly a sevenfold increase over BAU to almost zero. The AFOLU

wedge is unique in that it combines significant emission cuts with actual removals. Beneath these three wedges lies the national net-zero gap, showing the residual emissions that remain after implementing all measures. Closing this gap requires carbon dioxide removal and interventions outside the scope of this report.

Figure 4. National mitigation wedges from business-as-usual to net zero. The residual net-emissions band is the contribution required from removals and out-of-scope sectors



7.3

The national residual and how it is closed

The main finding is that fully transforming all three sectors nearly achieves net-zero emissions but not completely. By 2070, approximately 6–8 MtCO₂e/year remains. This residual mainly includes challenging non-CO₂ agricultural emissions, such as enteric fermentation and managed soils, which are essential to support a growing population's food needs. It also covers smaller, harder-to-eliminate energy and industrial sources. This residual consistently appears across

all 10,000 AFOLU Monte Carlo simulations, indicating that it is structural. To fully eliminate it, three main actions are necessary: enhance the AFOLU land sink to sequester residual agricultural emissions; greatly decarbonise the remaining difficult energy sources; and adopt economy-wide measures such as IPPU mitigation, permanent carbon removals, and international cooperation where relevant.

7.4

Sequencing the national transition

All three sectors converge on the same sequencing logic, which becomes the backbone of the national roadmap.

- **2025–2030: Readiness and no-regret action.** Build MRV, the Ghana Carbon Registry and corresponding-adjustment governance; deploy negative-cost and low-cost measures (energy efficiency, clean cooking, LED lighting, composting, landfill-gas capture, AWD rice, REDD+); reform policy and standards; establish Article 6 pipelines.
- **2030–2040: Scale-up of proven measures.** Renewables, grid reinforcement, storage, e-mobility and freight rail; urban sewerage and waste-to-energy; forest landscape

restoration and cocoa agroforestry at landscape scale; transact Article 6.2/6.4 pipelines.

- **2040–2050: Deep decarbonisation.** Near-complete power-sector decarbonisation; deep electrification of transport and industry; comprehensive wastewater treatment; full landfill-gas retrofit; gross deforestation near-eliminated and removals roughly doubled.
- **2050–2070: Residual management.** Manage hard-to-abate residuals; sustain and monitor carbon-stock permanence; execute the economy-wide residual-gap strategy; integrate all sector MRV into the national inventory and BTR tracking.

A high-angle, aerial photograph of a person in a wooden boat on a body of water. The person is wearing a cap and is using a long paddle to row. The water is dark and has small, choppy waves. The boat is made of light-colored wood and has some items inside, including what looks like a white container and some ropes. The overall tone of the image is somewhat somber and contemplative.

Chapter 8: Investment and Climate Finance Needs

The national net-zero plan requires approximately US\$328.5 billion in investments across three sectors from 2025 to 2070. This need is concentrated, so the financing strategy should target these areas specifically rather than using a uniform approach.

8.1

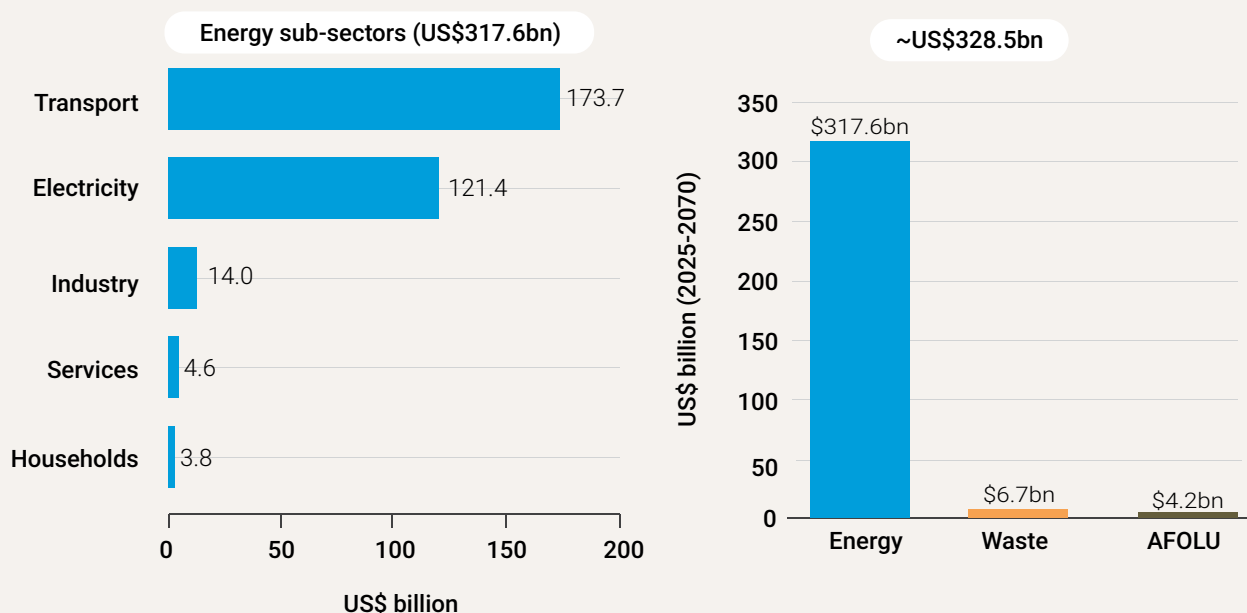
Consolidated investment requirement

Energy accounts for the great majority of total investment; AFOLU and Waste require far less capital but offer some of the earliest and cheapest abatement in the portfolio (Table 8.1 and Figure 5).

Table 8.1. Consolidated investment requirement by sector

Sector	Total investment (US\$bn)	Share	Period	Components
Energy	317.56	96.7%	2025–2070	Transport (173.7), electricity (121.4)
Waste	6.70	2.0%	2026–2070	Wastewater and solid-waste infrastructure
AFOLU	4.20	1.3%	2026–2070	Restoration, agroforestry, rice/soil
National total	328.46	100%	2025–2070	Energy-dominated

Figure 5. Net-zero investment required by sector, 2025–2070.



8.2

Phasing the investment

The national investment profile is heavily backloaded, reflecting energy-infrastructure lead times. Total investment rises from approximately US\$8.7 billion in 2025–2030 to more than US\$189 billion in 2051–2070 (Table 8.2). The

implication for sequencing is direct: prioritise no-regret, cost-effective, and readily executable measures in the near term, while building the institutional and financing pipeline needed to mobilise the far larger capital requirements of later phases.

Table 8.2. Consolidated investment by sector and phase

Phase	Energy (US\$bn)	Waste (US\$bn)	AFOLU (US\$bn)*	Combined (US\$bn)
P1: 2025–2030	6.69	1.00	~0.8	~8.5
P2: 2031–2040	32.91	1.95	~1.4	~36.3
P3: 2041–2050	90.19	2.10	~1.2	~93.5
P4: 2051–2070	187.79	1.65	~0.8	~190.2
Total	317.56	6.70	4.20	328.46

8.3

Financing structure and the catalytic gap

Private investment across various sectors is supported by catalytic public funds, concessional finance, and grants. In the national energy sector, private capital totals US\$178.09 billion (56.1%), public finance US\$54.52 billion (17.2%), and concessional and grant finance US\$84.95 billion (26.8%) (see Table 8.3). Concessional and grant finance act as vital catalytic gap funds that cannot be mobilised on commercial

terms without risk mitigation. The waste sector faces a financing shortfall of approximately US\$3.9 billion after accounting for carbon revenue and concessional support. AFOLU relies heavily on blended finance, with the main challenge being mobilising catalytic capital to attract private investment rather than project identification.

Table 8.3. Financing structure

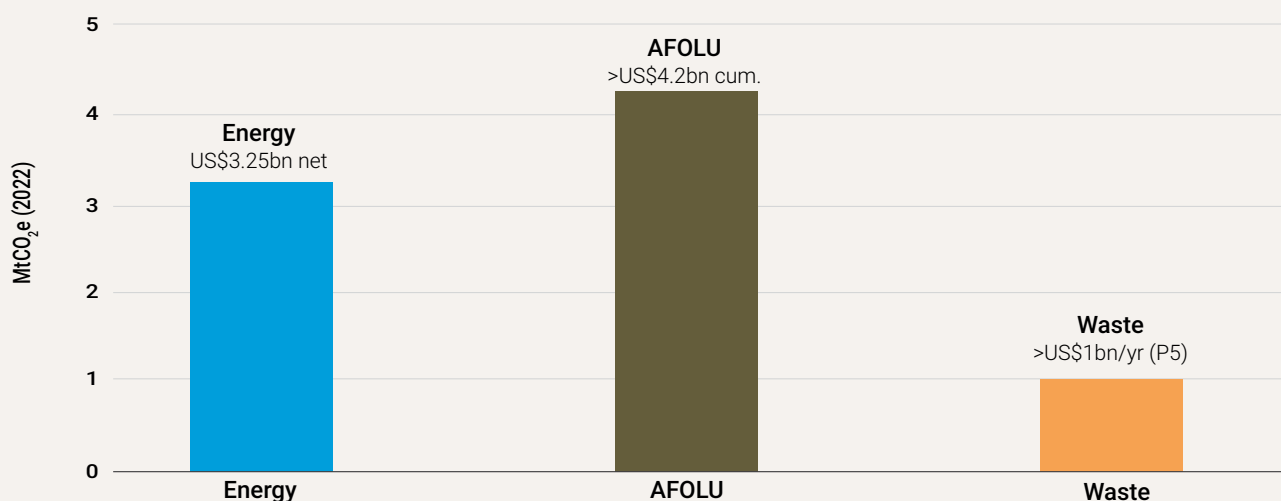
Finance source	Energy (US\$bn)	Role across all sectors
Private capital	178.09	Developers, independent power producers, infrastructure funds, fleet, and household finance
Public finance	54.52	Budget, public investment programme, utilities, MMDAs
Concessional	74.09	MDB/DFI soft loans, GCF, GEF, CIF, just-energy-transition-type facilities
Grants	10.87	Technical assistance, results-based finance, targeted affordability subsidy
Catalytic gap	84.95	Concessional plus grant – the binding mobilisation challenge

Carbon finance and Article 6

Carbon finance is a complement to, not a substitute for, core financing, but it is strategically significant in all three sectors. The energy portfolio (250 MtCO₂e) could generate approximately US\$3.25 billion net at US\$20/tCO₂e (US\$0.81 billion at US\$5/tCO₂e; US\$8.13 billion at US\$50/tCO₂e). The AFOLU pipeline could generate cumulative revenue exceeding its US\$4.2 billion requirement while supporting ITMO flows approaching 68 MtCO₂e/year by 2050. In Waste, twelve

Article 6.2-eligible measures could generate revenue rising from US\$60 million in Phase 1 to over US\$1 billion annually in later phases (Figure 6). All three sectors depend on the same supporting infrastructure: host-country authorisation, the Ghana Carbon Registry, corresponding-adjustment protocols, transparent benefit-sharing, and robust MRV together with a clear distinction between ITMOs and voluntary-market credits or NDC-attributed reductions.

Figure 6. Article 6 and carbon-finance opportunity by sector (indicative). All three opportunities depend on shared MRV and registry infrastructure.



Financing instruments and bankable packages

Financing instruments should be matched to each measure's risk profile, revenue model, and maturity: sovereign green and sustainability bonds for grid, renewable generation, public transit and building projects; concessional MDB/DFI loans for long-lived infrastructure; guarantees and political-risk insurance to manage offtaker and currency risks; results-based finance and pay-as-you-go or consumer finance for clean cooking, efficient appliances and distributed solar; ESCO models and on-bill financing for efficiency retrofits; and carbon finance for qualifying measurable actions. In Energy,

twelve viable investment packages totalling approximately US\$96.55 billion have been identified; the highest-readiness, no-regret packages including LED street lighting, efficient cooling, efficient appliances, clean cooking, and public-building retrofits, are ready for immediate implementation. Creditworthy offtake is the common requirement across every instrument; increasing private investment requires payment-security mechanisms, tariff reform, reduced utility losses, and local-currency financing.

A photograph of a man standing on a beach, looking out at the ocean. The beach is covered in a large amount of plastic waste, including bags and bottles. The sky is overcast and cloudy. The man is wearing a dark shirt and light-colored shorts.

Chapter 9: **Policy and Regulatory Requirements**

Delivery is as much an institutional and financing challenge as a technical one. The three sectors sit under a common climate governance framework but are led by different institutions, and successful integration depends on active coordination within Ghana's national climate change architecture.

9.1

National climate governance and coordination

An effective inter-agency coordination mechanism is crucial for implementing the integrated strategy, NDC 3.0, ETIP, and future net-zero commitments. Responsibilities must be clearly assigned to the Ministry of Environment, Science and Technology, the EPA, the Ministry of Energy and Green Transition, the Ministry of Finance, the Ministry of

Food and Agriculture, the Forestry Commission, the Energy Commission, and local authorities. This should be supported by a national framework for net-zero implementation and monitoring that enables adaptive management. As noted in this report, gaps in institutional coordination pose significant risks and require prompt, targeted action.

9.2

Lead institutions by workstream

Table 9.1 consolidates institutional responsibilities across the three sectors, drawing on each sector's own RACI (Responsible, Accountable, Consulted, Informed) matrix to support coordinated governance.

Table 9.1. Consolidated responsibility map across the three sectors

Workstream	Accountable / lead	Key partners
GHG inventory, BTR and MRV	EPA (Climate Change Unit)	Forestry Commission, MoFA, Energy Commission
Article 6 / ITMO issuance and registry	Carbon Market Office	EPA, sector institutions, Ministry of Finance
Energy transition and power	Ministry of Energy and Green Transition / Energy Commission	GRIDCo, ECG, NEDCo, PURC, independent power producers
REDD+, forests and restoration	Forestry Commission	EPA, COCOBOD, communities
Climate-smart agriculture	Ministry of Food and Agriculture	CSIR, COCOBOD, EPA
Cocoa agroforestry	COCOBOD	Forestry Commission, value-chain partners
Waste and sanitation delivery	MMDAs / Ministry of Local Government, Chieftaincy and Religious Affairs	EPA, private operators, informal sector
Climate finance mobilisation	Ministry of Finance	Bank of Ghana, MDBs/DFIs, GCF, private finance

Priority legal and regulatory reforms

9.3.1 Carbon market

Continue developing the Ghana Carbon Registry, finalise regulations for corresponding adjustments, simplify the process for host-country authorisation, and create benefit-sharing mechanisms aligned with the Environmental Protection Act, 2025 (Act 1124). This Act assigns the EPA the responsibility for coordinating climate response and supervising Article 6 activities.

9.3.2 Energy

Strengthen minimum energy performance standards, appliance labelling, and enforcement; reform tariff structures and payment-security arrangements; expand Energy Service Companies (ESCOs) and on-bill financing; and standardise Power Purchase Agreements and a landfill-gas-to-electricity sales framework.

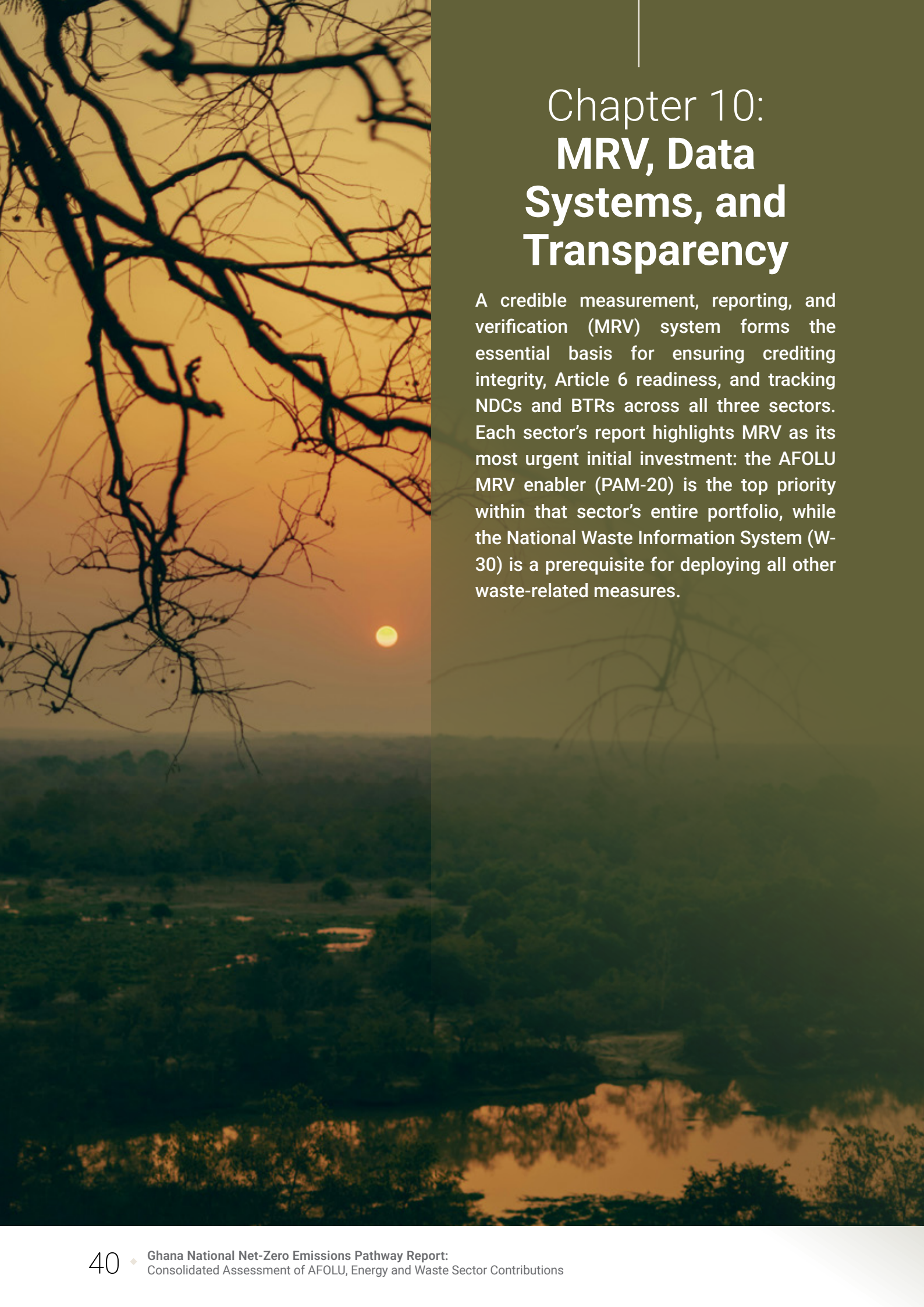
9.3.3 Land use

Secure land tenure; establish REDD+ benefit-sharing and Free, Prior, and Informed Consent (FPIC) protocols; and align LULUCF accounting with the Forest Reference Emission Level.

9.3.4 Waste management

Strengthen the sector regulator to consolidate the currently fragmented legislation; introduce Extended Producer Responsibility (EPR) regulations; mandate organic waste diversion; and issue MMDA tariff-setting guidelines.





Chapter 10: **MRV, Data Systems, and Transparency**

A credible measurement, reporting, and verification (MRV) system forms the essential basis for ensuring crediting integrity, Article 6 readiness, and tracking NDCs and BTRs across all three sectors. Each sector's report highlights MRV as its most urgent initial investment: the AFOLU MRV enabler (PAM-20) is the top priority within that sector's entire portfolio, while the National Waste Information System (W-30) is a prerequisite for deploying all other waste-related measures.

10.1

The transparency backbone

The national MRV framework should integrate project-level data with the national GHG inventory, the Enhanced Transparency Framework (ETF), and NDC tracking. Each sector generates distinct AFOLU activity data and remote sensing land-use monitoring data; energy production and

consumption data; and waste generation, composition, and treatment data that must feed a single national inventory and a consolidated Article 6 accounting ledger, avoiding double counting across ITMOs, voluntary-market credits, and nationally reported reductions.

10.2

Priority data improvements

Table 10.1 sets out the priority actions for strengthening MRV and data readiness. The highest priority is improving the wastewater emissions inventory, which underpins

the credibility of the net-zero pathway, greenhouse gas accounting and mitigation tracking alike.

Table 10.1. MRV and data readiness priorities

Data need	Sector	Current challenge	Recommended improvement	Lead
Wastewater inventory	Waste	IPCC Tier 1 defaults; population-based estimation	Facility-level BOD data and methane correction factors	EPA / MMDAs
LULUCF–FREL reconciliation	AFOLU	Large, uncertain gross flows	Align inventory with the REDD+ Forest Reference Emission Level	Forestry Commission / EPA
Agricultural sub-categories	AFOLU	Disaggregation pending	Official activity-data disaggregation	MoFA / EPA
Energy end-use data	Energy	Fragmented, low granularity	Integrated energy data architecture	Energy Commission
Waste activity data	Waste	No national waste data system	Deployment of the National Waste Information System	EPA / MMDAs



Chapter 11: **Socioeconomic, Just Transition, and Sustainable Development Impacts**

Ghana's pursuit of net zero aligns closely with its development strategy as much as it does with its emissions goals. The Sustainable Development Impact Assessment (SDIA) highlights significant alignment between climate objectives and broader development aims, provided implementation is careful and safeguards are in place. This chapter consolidates the social, gender, just transition, and SDG aspects across the three sectors.

11.1

Development co-benefits

The transition offers co-benefits well beyond emissions reduction: improved air quality, expanded clean-energy access, reduced energy poverty, strengthened food security, ecosystem restoration, greater climate resilience, green jobs, and new economic opportunities. The assessment identifies clear synergies with SDGs 1, 2, 3, 5, 7, 8, 9, 10, 11,

12, 13, and 15. Demand- and service-side measures such as clean cooking, household energy efficiency, sanitation and waste management, public transport, and climate-resilient water and health services perform best on development criteria because their benefits are immediate and visible at the household level.

11.2

Gender-responsive transition

Ghana's gender assessment finds that the net-zero strategy is mostly gender-responsive, highlighting key opportunities for transformation. The most impactful actions are those made at the household, community, and service delivery levels, including clean and e-cooking programmes that cut indoor air pollution and time burdens while supporting women's micro-enterprises; sanitation and resource recovery aimed at net-zero goals; solar mini-grids for productive activities; and disaster-risk finance with climate-resilient healthcare for women farmers and caregivers. Large-scale, capital-

intensive measures such as utility-scale generation, storage, hydrogen, and heavy industry are viewed as less directly beneficial for gender equality—not because they threaten it, but because their advantages are indirect and depend heavily on targeted workforce policies, procurement, and benefit-sharing. Ultimately, gender inclusiveness depends more on implementation strategies such as affordability, women-focused financing, skills training, participation, and accountability than on the specific sector.

11.3

Just transition and economic diversification

The most effective just-transition outcomes occur when policies explicitly focus on reducing vulnerability, safeguarding livelihoods, and expanding essential services such as clean cooking, mini-grids, sanitation, waste management, and climate-risk finance. Table 11.1 highlights SDIA findings related to gender and just transition across the portfolio. Transport modernisation efforts such as updating bus fleets, developing urban rail, and promoting electric mobility show positive results,

though these depend on retraining and income support for informal operators. Economic diversification is most successful when policies actively promote value-chain development, waste valorisation, recycling, composting, sanitation resource recovery, biochar, electric mobility ecosystems, and climate-smart agriculture, thereby opening opportunities for small and medium enterprises. In all cases, the way policies are implemented is as important as the choice of technology.

Table 11.1. Synthesised overview of findings from the SDIA gender and just-transition matrices

Group	Highest just-transition / gender value	Key safeguard required
Clean cooking / e-cooking	Health, time poverty, women's enterprise	Targeted affordability; technician skills pipeline
Sanitation and resource recovery	Dignity, decent work, circular markets	Occupational health and safety standards; product standards; market support
Solar mini-grids	Rural inclusion; productive use	Women beneficiary targets; tariff safeguards
Waste and recycling	Service jobs; SME formation	Inclusive formalisation of informal workers
Climate-smart agriculture / REDD+	Rural livelihoods; carbon income	Land tenure; gender-responsive benefit-sharing; FPIC
Public transport/rail	Mobility, safety, access	Informal operator integration; safety-by-design





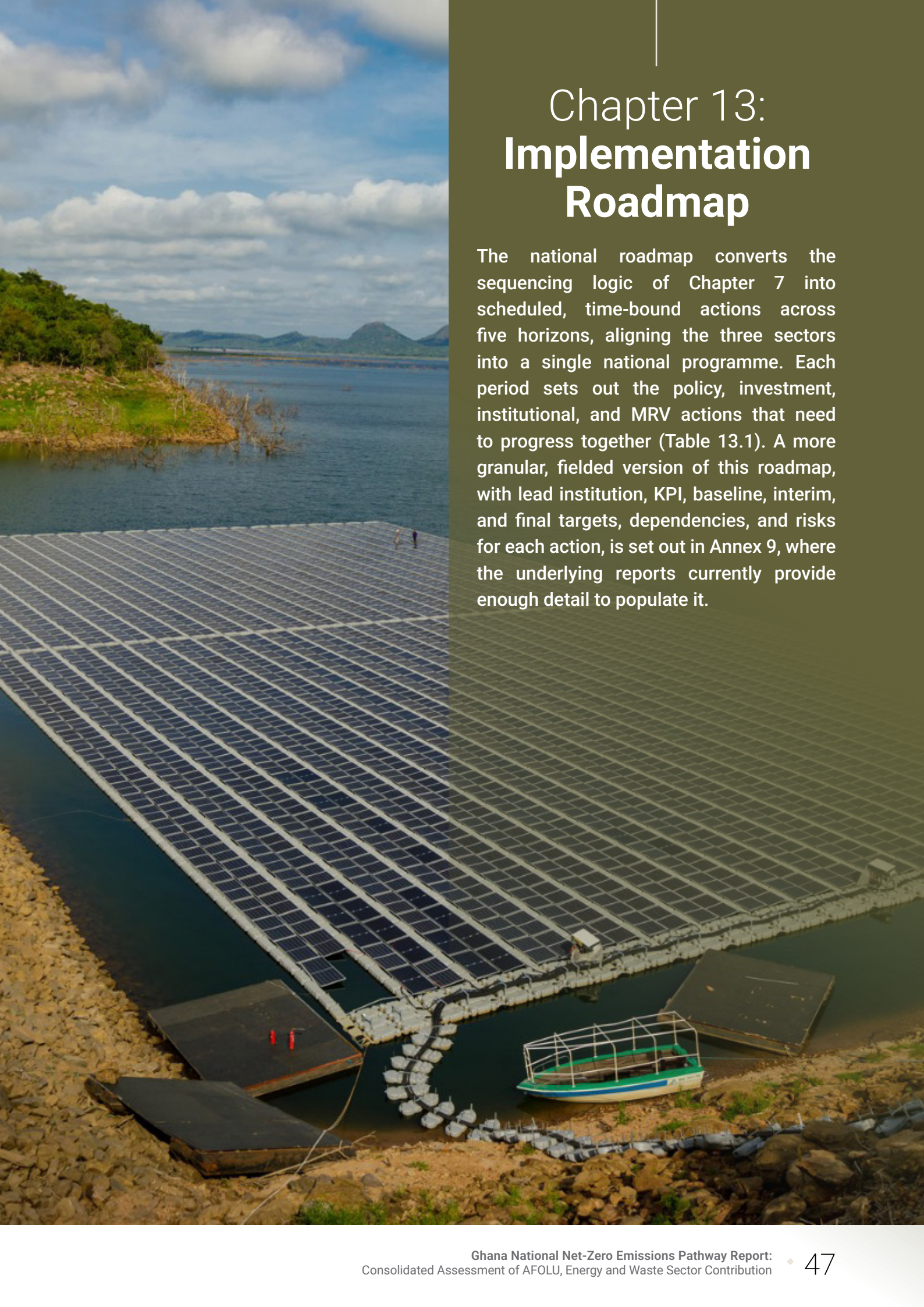
Chapter 12

Risks, Barriers, and Mitigation Measures

The integrated pathway faces a shared set of cross-cutting risks: financing, institutional coordination, capacity, market development, data and social inclusion, and sector-specific delivery challenges (Table 12.1). Most of these risks can be managed through targeted safeguards. The matrix below consolidates the most material risks identified across the three sectors.

Table 12.1. Consolidated national risk matrix across the three sectors

Risk	Sector(s)	Likelihood	Impact	Mitigation
Tree survival below assumption undermines removals	AFOLU	Medium	High	Aftercare financing; survival-rate MRV; adaptive replanting
Catalytic finance not mobilised at scale	All	Medium	High	Blended finance; de-risking; credible pipelines; carbon finance
Carbon lock-in from slow capital turnover	Energy	Medium	High	Early no-regret action; avoid new fossil lock-in
Deforestation leakage to unprotected areas	AFOLU	Medium	High	Jurisdictional REDD+; strengthened national monitoring
Displacement of informal waste worker	Waste	Medium	Medium	Inclusive formalisation; cooperatives; occupational health and safety; finance
Grid and storage constraints limit electrification	Energy	Medium	High	Integrated planning; concurrent generation/transmission upgrades
Methane capture / treatment underperformance	Waste	Medium	Medium	Performance contracts; MRV; source separation; collection coverage
Institutional coordination gaps delay MRV	All	Medium	Medium	Formalise RACI; joint technical working groups
Carbon-price volatility / weak demand	All	Medium	Medium	Diversify finance; avoid over-reliance on carbon revenue
Land tenure conflict and weak FPIC	AFOLU	Medium	High	Secure tenure; FPIC; equitable benefit-sharing
Data gaps propagate to projections	All	High	Medium	Prioritise official data; update model as data improves



Chapter 13: Implementation Roadmap

The national roadmap converts the sequencing logic of Chapter 7 into scheduled, time-bound actions across five horizons, aligning the three sectors into a single national programme. Each period sets out the policy, investment, institutional, and MRV actions that need to progress together (Table 13.1). A more granular, fielded version of this roadmap, with lead institution, KPI, baseline, interim, and final targets, dependencies, and risks for each action, is set out in Annex 9, where the underlying reports currently provide enough detail to populate it.

Table 13.1. National implementation roadmap, 2025–2070

Period	Priority national actions	Expected outcome
Immediate, 2025–2027	Operationalise MRV, the Ghana Carbon Registry and corresponding-adjustment governance; launch negative-cost energy measures, composting, landfill-gas capture, AWD rice, and REDD+ benefit-sharing; establish Article 6 pipelines; reform policy and standards.	Enabling architecture in place; first no-regret abatement secured
Short term, 2028–2030	Scale clean cooking, efficient lighting and appliances, dump closure, and EPR; begin renewables and grid pipeline; reconcile LULUCF with the FREL.	NDC targets met; waste ~49% below BAU; foundation set
Medium term, 2031–2040	Scale renewables, storage, e-mobility, freight rail, urban sewerage, waste-to-energy, forest restoration and cocoa agroforestry; transact Article 6.2/6.4 at scale.	Proven measures at scale; deforestation falling; removals growing
Long term, 2041–2050	Deep power- and transport-sector decarbonisation; comprehensive wastewater treatment; full landfill-gas retrofit; near elimination of gross deforestation.	Deep decarbonisation; waste ~88% below BAU; removals roughly doubled
Consolidation, 2051–2070	Manage residuals and permanence; execute the economy-wide residual gap strategy; integrate all sector MRV into the national inventory and BTR.	net-zero waste by 2060; near-zero energy; managed national residual





Chapter 14: Conclusions and Recommendations

This is the first unified national document setting out how Ghana's three largest-emitting sectors, AFOLU, Energy, and Waste, can move together from current emissions patterns to a credible, financed, and actionable net-zero pathway by 2070. Industrial Processes and Product Use (IPPU) and other non-energy fugitive sources sit outside this analysis; a full economy-wide net-zero strategy must incorporate them alongside the residual-management approach described here. Five conclusions follow.

- Energy, AFOLU, and Waste together account for approximately 96.5% of 2022 emissions and would, on current trends, nearly quadruple by 2070 without transformative action.
- These sectors can approach, but not fully reach, net zero on their own: a structural residual of roughly 6–8 MtCO₂e/year is expected to remain, dominated by agricultural sources. Ghana's strategy should plan explicitly for this managed residual.
- A significant share of early abatement is cost-negative or low-cost: many energy-efficiency measures save money outright; AFOLU measures average US\$5.80/tCO₂e; many waste measures cost under US\$5/tCO₂e. The transition can begin with savings, not subsidy.
- The estimated US\$328.5 billion financing requirement is achievable but depends on closing the catalytic (concessional plus grant) gap and building robust MRV and coordination mechanisms.
- The transition can advance health, gender equity, employment, food security, energy access, and economic diversification in step with mitigation, with clear synergies across twelve SDGs.

14.1

Recommendations

National policy and governance

- The Ministry of Environment, Science, and Technology (MEST) and EPA should adopt this consolidated pathway as the foundational analysis for Ghana's Long-Term Low-Emission Development Strategy and establish a cross-government coordination and monitoring mechanism to track delivery.

corresponding-adjustment governance, and establish sector-specific Article 6.2/6.4 pipelines building on existing bilateral agreements.

Sectoral mitigation priorities

- Sector lead institutions should prioritise the no-regret actions identified for 2025–2030 across all three sectors: energy efficiency, clean cooking, composting, landfill-gas capture, EPR, REDD+, cocoa agroforestry and AWD rice.

MRV and transparency

- EPA should prioritise MRV and data investment — beginning with the wastewater inventory, LULUCF–FREL reconciliation and energy-sector disaggregation — and ensure all sector MRV feeds the national inventory and BTR.

Investment and finance mobilisation

- The Ministry of Finance should lead development of a single national transition-finance programme that treats the approximately US\$85 billion catalytic gap as the central mobilisation challenge, deploying green bonds, concessional finance, guarantees, results-based finance, ESCO models, and consumer-finance instruments matched to each measure.

Just transition and development benefits

- Sector institutions should embed gender-responsive, just-transition safeguards from the outset: protecting informal waste workers, smallholder and women farmers, and forest communities, and securing FPIC, land tenure, and equitable benefit-sharing.

UNEP-CCC support priorities

- UNEP-CCC should support Ghana in extending this consolidated pathway into a full economy-wide Long-Term Strategy that incorporates IPPU and residual-gap strategies, and continue strengthening modelling capacity, MRV, Article 6 readiness, and access to climate finance.

Article 6 and carbon-market readiness

- The Carbon Market Office should strengthen the Ghana Carbon Registry and host-country-authorisation and

Annex 1: Harmonised Assumptions

Assumption	Value/basis	Applies to
Base year	2022 official inventory (NID1/BTR1)	All sectors
GWP set	AR5 (CH ₄ 27.9; N ₂ O 273)	All sectors
Horizon	2022–2070 (annual)	All sectors
Net-zero target	2070 (AFOLU, Energy); 2060 (Waste)	Sector-specific
Population, 2070	67.3 million	Energy driver; cross-cutting
Urbanisation, 2070	84.8% urban	All demand projections
GDP per capita, 2070	~US\$12,833	Energy and waste drivers
Central carbon price	US\$20/tCO ₂ e (range US\$5–50)	Carbon-finance estimates
Energy modelling baseline	35.8 MtCO ₂ e (2024, LEAP)	Energy projections only
Energy inventory baseline	24.76 MtCO ₂ e (2022)	Cross-sector comparison

Annex 2: Sector Mitigation Measures

The consolidated portfolio comprises 20 AFOLU measures (PAM-01 to PAM-20), the Energy MACC option set (efficiency, clean cooking, lighting, cooling, electric vehicles, freight rail, renewables, grid, storage, industrial fuel switching, hydrogen), and 30 Waste measures (W-01 to W-30). The full measure-level matrices covering abatement,

cost, lead institution, MRV indicator, Article 6 readiness, and safeguards are documented in the underlying sector reports and their accompanying workbooks; this report summarises the priority measures in Tables 4.2 and 5.1 and the waste scenario results in Table 6.1.

Annex 3: Investment and Finance Summary

Sector	Total (US\$bn)	Private	Public	Concessional + grant	Net carbon finance
Energy	317.56	178.09	54.52	84.95	~3.25 (at US\$20/t)
Waste	6.70	Blended	Blended	~3.9 gap	US\$0.06bn → >US\$1.0bn/yr
AFOLU	4.20	Blended	Blended	Blended	Exceeds cost (cumulative)
Total	328.46	—	—	—	—

Annex 4: MRV Indicator Framework

Each mitigation measure carries a cumulative-achievement tracking indicator — for example, hectares restored, farms under agroforestry, area under AWD, biodigesters operational, MW of renewable capacity, tonnes diverted from landfill, or population served by treated wastewater — with a 2022 baseline, 2030 and 2050 milestone targets, a

reporting cadence, and a responsible institution. Portfolio-weighted MRV coverage should rise from current levels (estimated at approximately 50% in AFOLU) [Verify figure and source] toward approximately 75% by 2030, integrated into the national inventory and BTR tracking.

Annex 5: **Priority Project Pipeline**

Energy

- Utility-scale renewables and storage
- Grid reinforcement and smart metering
- Electric public fleets and charging infrastructure
- Road-to-rail freight corridors
- Public LED street lighting
- Efficient cooling and appliances
- Clean-cooking distribution

Waste

- Composting and organic-waste programme scale-up
- Landfill-gas capture (Kpone, Oti)
- Open-dump closure
- Faecal-sludge management
- Urban sewerage (Accra, Kumasi, Tamale)

- Waste-to-energy
- Anaerobic digestion

AFOLU

- REDD+ jurisdictional programmes
- Forest landscape restoration
- Cocoa agroforestry transformation
- Afforestation and reforestation
- AWD rice
- Manure-management biodigesters
- Mangrove restoration

All pipeline projects should be screened for Article 6/ voluntary-carbon-market eligibility, bankability, MRV readiness, and just-transition safeguards before development.

