

PMP

PEST MANAGEMENT PLAN

for the proposed

AIH

AGRO-INDUSTRIAL HUB

AT ADIABO, ODUKPANI LGA, CROSS RIVER STATE

BY



CR-SAPZ

CROSS RIVER-SPECIAL AGRO-INDUSTRIAL PROCESSING ZONE PROGRAM

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PEST MANAGEMENT PLAN (PMP)

FOR THE PROPOSED

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AT ADIABO, ODUKPANI LGA, CROSS RIVER STATE

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ABBREVIATIONS & ACRONYMS

Acronym	Full Meaning
AfDB	African Development Bank
CABI	Centre for Agriculture and Bioscience International
CAPA	Corrective and Preventive Action
CRADP	Cross River Agricultural Development Programme
CXS 193-1995	Codex Alimentarius “General Standard for Contaminants and Toxins in Food and Feed”
DE	Diatomaceous Earth
E&S	Environmental and Social
ECOWAS	Economic Community of West African States
EHS	Environmental, Health and Safety (Guidelines)
ESF	Environmental and Social Framework (World Bank)
ESS3	Environmental and Social Standard 3
FAO	Food and Agriculture Organization of the United Nations
FEFO	First-Expired, First-Out
FIFO	First-In, First-Out
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
GIIP	Good International Industry Practice
GRM	Grievance Redress Mechanism
HHP	Highly Hazardous Pesticide(s)
ICCO	International Cocoa Organization
INPhO	(FAO) Information Network on Post-harvest Operations
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
ISS	Integrated Safeguards System (AfDB)
KPI(s)	Key Performance Indicator(s)
LGB	Larger Grain Borer (<i>Prostephanus truncatus</i>)
MC	Moisture Content
NAFDAC	National Agency for Food and Drug Administration and Control (Nigeria)
NESREA	National Environmental Standards and Regulations Enforcement Agency
NIOSH	National Institute for Occupational Safety and Health (US)
OHS	Occupational Health and Safety

OP 4.09	Operational Policy 4.09: Pest Management (World Bank)
OS-1/OS-3/OS-4/OS-5	Operational Safeguards 1/3/4/5 (AfDB ISS)
OSHA	Occupational Safety and Health Administration (US)
P&I (UK P&I Club)	United Kingdom Protection and Indemnity Club
PICS	Purdue Improved Crop Storage
PMP	Pest Management Plan
PMU	Project Management Unit
PPE	Personal Protective Equipment
QC	Quality Control
RH	Relative Humidity
SAPZ	Special Agro-Industrial Processing Zone
SCBA	Self-Contained Breathing Apparatus
SDS	Safety Data Sheet
SON	Standards Organization of Nigeria
STEL	Short-Term Exposure Limit
TWA	Time-Weighted Average
WB (WBG)	World Bank (World Bank Group)
WHO	World Health Organization

EXECUTIVE SUMMARY

ES 1: Introduction

The Agro-Industrial Hub (AIH) at Adiabo, Odukpani LGA, Cross River State, is a 130-hectare facility designed under the Special Agro-Industrial Processing Zone (SAPZ) initiative. The scale and intensity of agricultural production, storage, and processing activities create significant risks of pest infestations that can undermine productivity, food safety, and environmental sustainability. To address these risks, a Pest Management Plan (PMP) has been developed as a guiding framework. The plan aligns with AfDB’s ISS (2023), World Bank ESS3, and FAO IPM principles to ensure pest control measures meet international standards on resource efficiency, pollution prevention, and reduced chemical dependency, while remaining practical for local application.

The PMP objectives include:

- Phasing out Highly Hazardous Pesticides (HHPs) within five years and promoting safer alternatives.
- Ensuring at least 70% of AIH-linked farmers adopt Integrated Pest Management (IPM) within three years.
- Establishing digital pest surveillance and hotspot mapping within two years.
- Training 5,000 farmers and extension workers in IPM and pesticide safety by year three.
- Setting up safe storage, handling, and disposal systems for pesticides within two years.
- Reducing pesticide-related health incidents among farmers and workers by 50% within four years.
- Institutionalizing a multi-stakeholder pest management coordination committee within the first year.

The PMP provides a framework for sustainable pest control across the AIH lifecycle—pre-construction, construction, operations, and decommissioning. It ensures alignment with AfDB ISS (2023), World Bank ESS3, and FAO IPM principles. Uncontrolled pest infestations and unsafe pesticide use can lead to yield losses, environmental degradation, and health hazards. The PMP provides structured, science-based, and community-inclusive approaches to minimize these risks.

The AIH supports cocoa, rice, cassava, yam, maize, and legumes. Major pests include cocoa mirids, fall armyworm, cassava green mite, yam beetles, rice stem borers, and storage pests such as bruchids. These pests cause significant pre- and post-harvest losses if unmanaged. The environmental and social consequences of unstructured pest management practices historically used in Cross River State, including stream contamination, biodiversity loss, and occupational exposure of vulnerable groups (women, youth, and farm workers). The PMP sets out measures to minimise pesticide use, restrict highly hazardous pesticides (HHPs), strengthen training and PPE provision, and introduce safe chemical storage and disposal. By doing so, the PMP safeguards public health, sustains agro-ecosystem integrity, and protects the AIH's long-term operational viability and market credibility.

Potential impacts of pests and pesticide use on AIH activities are also detailed. Pests such as cocoa mirids, rice stem borers, cassava mealybugs, yam beetles, maize weevils, and bruchids can cause yield losses of 5–40%, undermining processing capacity and revenue projections. Indiscriminate pesticide use brings risks of residues, pest resistance, and loss of export markets. The PMP therefore balances effective pest suppression with environmental, health, and safety safeguards.

ES 2: Project Description

The Adiabo Agro-Industrial Hub (AIH), located in Odukpani LGA, Cross River State, covers approximately 130 hectares and is a core component of the Special Agro-Industrial Processing Zone (SAPZ) program. It is designed to integrate production, processing, storage, and marketing to strengthen food systems, reduce post-harvest losses, and expand opportunities for value addition in priority commodities.

The AIH includes commodity processing centres, warehouses, cold storage, quality control laboratories, waste management facilities, veterinary and health services, and research and training units. Supporting infrastructure such as internal roads, drainage, water supply, electricity, and sewage treatment ensures operational efficiency.

Planned infrastructure incorporates conservation measures, vegetation management, and climate-resilient designs. Facilities for waste management, pesticide storage, and safe disposal are integral components, reducing risks to public health and the environment. The project responds to persistent challenges of low productivity, high post-harvest losses, weak rural infrastructure, and

poor market linkages. By centralizing services, the AIH improves farmer access to storage, processing, and extension services, enhancing competitiveness and food security.

The AIH delivers broad benefits:

- Socioeconomic: employment creation, reduced post-harvest losses, and rural income growth.
- Government: increased revenues, infrastructure development, and improved agricultural trade.
- Community: better access to services, training, and corporate social investments.
- Private Investors: reduced transaction costs and access to shared facilities.

Sustainability measures include strengthened IPM adoption, reduced pesticide dependency, safe disposal of chemical containers, resource efficiency, and compliance with national and international safeguards. Three options were assessed:

- No Project – continued pest-related losses, unsafe pesticide use, and missed opportunities.
- Delayed Project – escalation of pest risks and extended farmer vulnerability.
- Immediate Implementation – structured pest management, IPM mainstreaming, and socioeconomic benefits.

Four potential sites were considered. Adiabo was selected for its accessibility, moderate topography, and suitability for pest surveillance and management. Other sites presented challenges such as flooding, poor road access, and limited integration with farming communities.

ES 3: Institutional Arrangements and Responsibilities

The effectiveness of the Pest Management Plan (PMP) for the Adiabo Agro-Industrial Hub (AIH) relies on strong institutional coordination, regulatory oversight, and stakeholder participation. A multi-layered framework has been established to ensure that pest management interventions are sustainable, transparent, and compliant with international and national standards.

The PMP is aligned with AfDB's Integrated Safeguards System (ISS, 2023), the World Bank Environmental and Social Standard 3 (ESS3), and the FAO International Code of Conduct on Pesticide Management. Nationally, it adheres to NAFDAC pesticide regulations, NESREA environmental protection standards, and Nigeria's Agricultural Policy. The institutional roles and responsibilities indicate that:

- Cross River State Ministry of Agriculture: Provides technical leadership in IPM design, pest surveillance coordination, and farmer extension services.
- Cross River State Ministry of Environment: Oversees environmental compliance, pesticide residue monitoring, and waste disposal.
- State Agricultural Development Programme (ADP): Delivers farmer field training, implements surveillance through extension workers, and supports community outreach.
- SAPZ Steering Committee: Coordinates multi-stakeholder engagement, policy oversight, and inter-agency linkages between government, academia, private sector, and farmer groups.
- Research Institutions and Development Partners: Provide technical inputs, innovation support, and monitoring frameworks.

Farmer Field Schools, Training-of-Trainers programs, and community IPM campaigns are designed to equip farmers, extension officers, and youth scouts with skills in biological control, safe pesticide handling, and digital reporting. Special attention is given to gender inclusion and youth participation in surveillance and decision-making.

A centralized PMP digital dashboard and mobile-based reporting system support real-time pest incidence tracking. Regular joint review meetings and data-sharing protocols strengthen accountability and adaptive management. The institutional framework ensures effective surveillance, safe pesticide use, IPM adoption, and compliance with regulatory and safeguard requirements. It provides a governance structure that fosters collaboration and ensures long-term sustainability of pest management interventions across the AIH.

ES 4: Pest Assessment and Surveillance

Effective pest management within the Adiabo AIH depends on robust assessment and surveillance systems capable of identifying, monitoring, and addressing pest risks across priority commodities. The framework integrates scientific methods, community-based approaches, and digital technologies to safeguard productivity and reduce pesticide dependency. The AIH supports cocoa, rice, cassava, yam, maize, and legumes, each susceptible to specific pest pressures:

- Cocoa: mirids, black pod disease vectors.
- Rice: stem borers, blast pathogens, rodents.

- Cassava: green mites, mealybugs, whiteflies.
- Yam: yam beetles, nematodes.
- Maize: fall armyworm, stem borers.
- Legumes: pod borers, bruchids (storage pests).

If unmanaged, these pests contribute to significant field and post-harvest yield losses.

The PMP establishes a multi-tiered surveillance system that includes:

- Field scouting and systematic crop inspections.
- Use of pheromone and light traps for early detection.
- Community-based reporting systems engaging youth IPM scouts and farmers.
- Application of Economic Threshold Levels (ETLs) to guide interventions and minimize unnecessary pesticide use.

A centralized PMP digital dashboard collects and analyzes field data. GIS and remote sensing support hotspot mapping, while indicators such as the Normalized Difference Vegetation Index (NDVI) and Vegetation Condition Index (VCI) detect crop stress linked to pest infestations.

Phased Surveillance Approach

- Pre-construction: baseline pest surveys.
- Construction: demonstration plots and early monitoring.
- Operation: routine field and storage inspections supported by community scouts and extension workers.
- Decommissioning: pest risk audits and handover protocols.

The surveillance system ensures early detection of outbreaks, supports data-driven IPM decision-making, reduces reliance on chemical pesticides, and strengthens resilience to climate-driven pest dynamics. It provides a practical mechanism to secure crop productivity, farmer livelihoods, and environmental sustainability within the AIH.

ES 5: Existing Controls and Nature-Based Solutions for Pest Management

The AIH Pest Management Plan emphasizes strengthening existing control measures while promoting nature-based solutions as sustainable alternatives to chemical pesticides. This section outlines the current pest control practices in use and highlights ecologically sound strategies that support resilience, reduce environmental risks, and align with international best practices. Farmers

within the AIH value chains currently employ mixed approaches to manage pest pressures. These include:

- Chemical pesticides approved by NAFDAC, often applied without threshold-based guidance.
- Cultural practices such as crop rotation, timely planting, and sanitation to reduce pest breeding grounds.
- Traditional botanical extracts (e.g., neem, pepper-based sprays) used in smallholder contexts.
- Community-level practices such as coordinated bush clearing and residue management to reduce infestation sources.

While effective to some extent, these methods are inconsistently applied and often lack systematic monitoring, leaving gaps that increase risks of pest outbreaks and pesticide misuse.

The PMP promotes integrated ecological practices that balance productivity with sustainability.

These include:

- Biological control agents such as parasitoids, predators, and microbial formulations (e.g., *Bacillus thuringiensis*).
- Botanical pesticides like neem seed extract and essential oils with low toxicity and biodegradability.
- Agroecological practices including intercropping, push–pull systems, cover cropping, and the use of resistant varieties.
- Habitat management to conserve beneficial insects and natural enemies of pests.
- Soil health improvement measures such as composting and organic amendments that strengthen plant resilience against pests.

Nature-based solutions complement existing controls by reducing reliance on synthetic pesticides, lowering costs, and improving long-term sustainability. They are embedded within the PMP's Integrated Pest Management framework, ensuring interventions are context-specific, scalable, and aligned with farmer capacity.

The combined use of existing controls and nature-based solutions is expected to enhance pest suppression, reduce pesticide-related health and environmental risks, and build resilient agricultural systems within the AIH. These approaches support compliance with AfDB ISS, World

Bank ESS3, and FAO IPM principles while ensuring that pest management remains both effective and environmentally responsible.

ES 6: Phytopharmaceutical and Agricultural Extension Services Capacity

The capacity of phytopharmaceutical services and agricultural extension systems is fundamental to the success of the AIH Pest Management Plan. Strengthened institutions, trained personnel, and functional delivery systems are required to ensure safe pesticide use, effective Integrated Pest Management (IPM), and compliance with regulatory and safeguard standards.

Current phytopharmaceutical services in Cross River State are limited by inadequate regulation enforcement, insufficient laboratory facilities for pesticide residue testing, and weak monitoring of pesticide imports and distribution. The PMP addresses these gaps by:

- Strengthening NAFDAC oversight on pesticide registration and quality control.
- Establishing residue testing laboratories linked to the AIH for routine monitoring of produce and the environment.
- Introducing safe storage and distribution systems to prevent misuse of substandard or counterfeit products.
- Promoting the use of low-toxicity and environmentally safer formulations consistent with FAO and WHO guidelines.

Agricultural extension is central to farmer capacity building and adoption of sustainable practices. Current challenges include low extension worker-to-farmer ratios, inadequate training in IPM, and poor digital integration. The PMP strengthens extension services by:

- Training extension officers in IPM, pesticide risk reduction, and digital surveillance tools.
- Establishing Farmer Field Schools (FFS) and Training-of-Trainers (ToT) programs for continuous farmer education.
- Engaging youth IPM scouts as community-based monitors to support pest surveillance and reporting.
- Leveraging ICT platforms such as mobile apps and SMS for real-time pest reporting and advisory services.

The framework links phytopharmaceutical services with extension networks, ensuring synergy between pesticide regulation, farmer education, and pest surveillance. Partnerships with universities, research institutes, and private sector actors support innovation and knowledge transfer.

Improved phytopharmaceutical and extension capacity will result in safer pesticide supply chains, enhanced farmer knowledge, higher adoption of IPM, and reduced health and environmental risks. This capacity-building focus ensures that the AIH maintains a resilient, well-regulated, and knowledge-driven pest management system.

ES 7: Integrated Pest Management (IPM) Strategies

The IPM framework for the Adiabo AIH establishes a balanced, science-driven approach that combines cultural, mechanical, biological, and chemical measures to manage pests sustainably. It is designed to safeguard yields and crop quality, minimize risks to human and environmental health, and comply with AfDB and national safeguard standards.

Preventive cultural measures form the foundation of AIH's pest management. These include crop rotation, intercropping, resistant varieties, sanitation, and habitat management to suppress pest populations. Cultural practices reduce infestation risks and improve resilience while lowering reliance on external inputs.

Direct physical interventions such as handpicking, pruning, tillage, traps, and barriers are emphasized. These low-cost methods provide immediate pest reduction, especially in early infestation stages, and complement cultural strategies.

The plan promotes natural enemies and registered biopesticides, including microbial and botanical products such as *Bacillus thuringiensis* and neem extracts. Augmentative releases of *Trichogramma* and conservation practices enhance ecological balance. These approaches preserve beneficial insects and strengthen long-term pest suppression.

Synthetic pesticides are considered only when economic thresholds are exceeded and alternative methods prove inadequate. Only NAFDAC-approved, low-toxicity products are permitted,

excluding POPs and Highly Hazardous Pesticides. Application protocols emphasize calibrated spraying, PPE use, and record-keeping to ensure accountability, reduce exposure, and prevent misuse.

The PMP adopts defined Economic Threshold Levels (ETLs) for each crop–pest combination, ensuring interventions are timely, evidence-based, and economically justified. Weekly scouting, trap counts, and digital reporting guide action thresholds and avoid indiscriminate spraying.

Continuous feedback mechanisms—such as post-intervention monitoring, farmer surveys, and annual review workshops—support iterative refinement. Data integration through mobile apps and dashboards ensures real-time analysis, trend tracking, and evidence-based updates to IPM strategies.

The PMP sets out a practical, multi-layered action plan:

- **Integrated Pest / Vector Management Activities:** Deploy youth IPM scouts, pheromone traps, biological control agents, push–pull intercropping, hermetic storage bags, and resistant crop varieties; enforce buffer zones and no-spray strips along waterways.
- **Monitoring, Evaluation, and Reporting:** All pest incidence and control actions will be geo-referenced and uploaded to an AIH PMP dashboard; quarterly reports will be sent to the Steering Committee and AfDB.
- **Institutional Arrangements:** Defined roles for the AIH EHS Officer, ADP extension agents, community focal persons, and national quarantine services.
- **Cost Estimates:** Approximately ₦11 million has been earmarked for capacity building alone, with additional budget for traps, biopesticides, and residue testing.
- **Grievance Mechanism:** Linked to the AIH’s overall Project GM, enabling communities and workers to report pest-related incidents or pesticide concerns without fear of reprisals.
- **Capacity Building at National Level:** Collaboration with NAFDAC, NAERLS, and research institutes to strengthen laboratory testing, pest identification, and extension curricula.

Recognizing high storage pest risks in Cross River’s humid climate, the PMP outlines safe moisture content targets, hermetic storage, sanitation, and structural controls for rice, maize, groundnut, yam chips, and melon seeds. Biological and physical measures are prioritized, while

chemical fumigation is tightly regulated under GIIP, AfDB OS 3, and NAFDAC/NESREA standards. Mycotoxin management for maize and groundnut is embedded to maintain food safety.

ES 8: Productivity and Sustainability Benefits of Pest Management Options

Three strategic options were evaluated: exclusive biological and nature-based solutions, integrated approaches combining biological methods with proportionate chemical use, and exclusive chemical control. The analysis applied agreed criteria to ensure decisions are evidence-based and context-appropriate. Options were assessed against five dimensions:

- Agronomic effectiveness – yield stability, suppression of key pests, and resilience to outbreaks.
- Environmental impact – implications for soil health, biodiversity, water quality, and ecosystem balance.
- Worker and community health and safety – exposure risks, pesticide residues, and occupational hazards.
- Economic performance – input costs, yield outcomes, market access, and long-term viability.
- Institutional and social considerations – alignment with policy frameworks, AfDB safeguards, regulatory compliance, and community acceptance.

Option A: Sole Use of Biological Pest Control and Nature-Based Solutions (BPC/NBS): This option prioritises ecological methods such as resistant varieties, intercropping, botanicals, and conservation of natural enemies. It offers the highest environmental protection and eliminates pesticide exposure risks but may underperform during sudden pest outbreaks due to slower suppression rates. Economically, it is low-cost but labour-intensive, and requires strong extension support to scale effectively.

Option B: Combination of BPC/NBS with Proportionate Chemical Use (Integrated Pest Management): This mixed approach applies biological and cultural practices as first lines of defence, with low-toxicity, NAFDAC-approved pesticides used only when economic thresholds

are exceeded. It consistently delivers yield gains of 15–40%, balances productivity with ecological safety, reduces overall chemical dependency, and aligns with national IPM policy and AfDB safeguards. This option also strengthens long-term pest suppression by conserving beneficial organisms.

Option C: Exclusive Chemical Control: This option relies entirely on synthetic pesticides for pest suppression. While initially effective with rapid knock-down, it creates escalating risks of resistance, environmental degradation, food safety concerns, and high input costs. Worker and community health risks are significant, and institutional alignment is weak, making this option unsustainable beyond emergency situations.

The comparative analysis clearly supports Option B (Integrated Pest Management) as the most appropriate strategy for the AIH. It provides the best cost–benefit balance, ensures compliance with AfDB safeguards, reduces health and environmental risks, and secures both productivity and sustainability. Elements of Option A should be strengthened within this integrated framework to further minimise chemical reliance, while Option C should be avoided except in regulated emergencies.

ES 9: Health, Environmental and Safety Considerations

The Pest Management Plan (PMP) for the Adiabo Agro-Industrial Hub (AIH) places strong emphasis on safeguarding human health, ensuring environmental integrity, and enforcing safety standards throughout pest control operations. This framework integrates preventive measures, regulatory compliance, safe handling protocols, and continuous monitoring to minimize risks to workers, communities, and ecosystems.

Pesticide-related hazards include acute poisoning, respiratory distress, skin and eye irritation, and long-term risks such as neurological or reproductive disorders. Environmental risks stem from leaching into soil, contamination of surface and groundwater, accumulation of residues in food, and adverse effects on pollinators, fish, and beneficial insects. Recognizing these hazards guides the PMP in prioritizing preventive and protective measures.

All pest management activities comply with AfDB Operational Safeguard 3, World Bank ESS3, the FAO/WHO International Code of Conduct on Pesticide Management, and Nigeria's regulatory frameworks enforced by NAFDAC and NESREA. Compliance ensures that only approved products are used, handling and storage meet safety standards, and residue levels remain within permissible limits.

The PMP requires that only trained and certified applicators manage pesticide use. Buffer zones of 10–30 metres are enforced around water bodies and human settlements. Pre-harvest intervals are strictly observed to protect consumers from residues. Community awareness programs and grievance mechanisms are established to address concerns and enhance trust.

Personal Protective Equipment is compulsory for all pesticide handlers. Gloves, boots, respirators, overalls, and protective eyewear must be provided and consistently used. Training ensures correct use and maintenance of PPE to reduce exposure risks. Designated, ventilated storage facilities must be established within the AIH to prevent leaks, unauthorized access, or accidental contamination. Containers must be properly labelled, segregated by hazard class, and secured under lock and key. Restricted access ensures only authorized personnel handle pesticides.

Only NAFDAC-registered and lower-toxicity products are permitted. Highly Hazardous Pesticides (HHPs) and Persistent Organic Pollutants (POPs) are banned. Application must be conducted with calibrated sprayers, under appropriate weather conditions, and with adherence to drift-reduction techniques to protect non-target areas.

The PMP mandates clear procedures for accidental spills, leaks, or poisoning. Spill kits, first aid facilities, eyewash stations, and emergency hotlines are required at storage and application sites. Workers and communities are trained to recognize exposure symptoms and respond promptly. Empty pesticide containers must be triple rinsed, punctured, and returned for licensed disposal or incineration. Open burning and burial are strictly prohibited. Regular residue monitoring of soil and water is undertaken to detect contamination and guide corrective action.

Protective buffer strips are maintained around rivers, wells, and ecologically sensitive areas. Measures to conserve pollinators include restricting pesticide use during flowering periods and promoting bee-friendly alternatives. These safeguards reduce ecological disruption and strengthen ecosystem services essential for crop production.

The PMP incorporates community notification before spraying, controlled grazing to prevent livestock exposure, and educational outreach to enhance awareness of safe practices. This ensures that both community health and ecosystem balance are protected.

Detailed records of procurement, distribution, application, and disposal of pesticides are maintained. Documentation ensures traceability, accountability, and compliance with audit and reporting requirements. Regular field inspections, compliance audits, and farmer feedback are integrated into a cycle of continuous improvement. Data from residue monitoring and field surveillance guide adaptive adjustments, ensuring the PMP evolves to meet emerging risks while maintaining health, safety, and environmental standards.

ES 10: Stakeholder Engagement and Awareness

Stakeholder engagement is a cornerstone of the PMP for the Adiabo AIH, ensuring inclusivity, ownership, and accountability in pest management. The engagement plan combines workshops, field demonstrations, local radio, folk drama, IEC materials, and digital feedback platforms to promote knowledge transfer and participation.

Stakeholder mapping identified smallholder farmers as primary adopters, agro-processors as guarantors of pest-free raw materials, women and youth groups as field scouts and trainers, traditional leaders as mobilizers, NGOs as trainers and monitors, and universities and research institutions as designers of pest control packages. Government ministries provide policy enforcement and extension, while AfDB and FAO contribute technical and financial support.

Methods include sensitization workshops across ten wards, quarterly and annual review forums, gender-sensitive discussions, and field days to demonstrate IPM practices. Mass communication through radio pest alerts, call-in programs, and theatre in local dialects widens outreach. IEC materials in English and local languages support illiterate farmers. Digital mechanisms—SMS

short codes, WhatsApp groups, and voice-based services—facilitate real-time reporting and feedback.

The inclusion and equity strategy mandates at least 40% female participation, training of women-led farms, and youth empowerment through IPM scout roles and agropreneurship hubs. Social safeguards emphasize cultural appropriateness, exclusion of child labour, and integration with SAPZ grievance redress mechanisms.

Monitoring of engagement tracks participation numbers, gender balance, satisfaction levels, and incorporation of feedback. Evidence of consultations—venues, attendance, minutes, photos, and costs—is fully documented. The grievance mechanism ensures timely, transparent resolution of concerns. This approach guarantees that pest management under AIH is technically sound, socially legitimate, and sustainable.

ES 11: Budgeting and Financing

The PMP is underpinned by robust budgeting and financing aligned with AfDB's results-based financing model. Costs were estimated through activity-based costing, ensuring expenditures are tied to verifiable outcomes.

Five cost components structure the budget: (i) surveillance infrastructure, including pheromone traps, mobile devices, and GIS licenses; (ii) training and capacity building, covering Farmer Field Schools, Training-of-Trainers, PPE workshops, and manuals; (iii) procurement of inputs, such as biocontrol agents, neem-based botanicals, PPE, and sanitization kits; (iv) monitoring and evaluation, including field visits, data printing, external evaluations, and review workshops; and (v) public engagement, with radio campaigns, sensitization forums, and youth/women inclusion campaigns.

The consolidated budget amounts to ₦22.68 million (≈\$14,587.52), with a 10% contingency provision. Funding sources include AfDB through the SAPZ envelope, Cross River State budget allocations, development partners (World Bank, FAO, IITA), and private sector co-financing through out-grower support schemes.

Disbursement and financial management are centralized under the AIH Project Financial Management Unit (PFMU), with quarterly reporting to AfDB, Cross River Auditor General, and the SAPZ Steering Committee. Expenditures must be linked to activity plans, verified through field audits, and published for transparency. This system ensures accountability, donor confidence, and financial sustainability for pest management in AIH.

ES 12: Monitoring and Evaluation

Monitoring and Evaluation (M&E) provides the adaptive backbone of the PMP, enabling continuous learning and accountability. Indicators tracked include pest incidence, IPM adoption rates, pesticide use, yields, health incidents, and environmental compliance. Data are sourced through farmer reports, ADP surveys, agro-dealer logs, health facility records, and MoEnv inspections.

Reporting uses standardized templates with GPS-enabled data capture, pest type, severity, methods applied, and farmer feedback. These feed into a PMP Monitoring Dashboard, accessible by ADP agents, ministries, and the SAPZ Steering Committee.

Institutional roles are clearly defined: ADP agents collect field data; the Ministry of Agriculture validates reports; the Ministry of Environment conducts residue monitoring; and the SAPZ Steering Committee provides technical oversight.

Periodic reviews include annual workshops to revise thresholds, update pest profiles, and integrate new threats such as invasive species. Independent mid-term and end-term evaluations by UNICROSS or consultants assess cost-effectiveness, institutional performance, and farmer knowledge retention. Results inform strategic course correction, resource allocation, and donor engagement.

M&E is fully integrated into the broader SAPZ Environmental and Social Management Plan (ESMP), ensuring coherence with safeguards. This dynamic feedback loop ensures interventions remain relevant, effective, and aligned with evolving agro-ecological conditions.

ES 13: Conclusion

The PMP for the Adiabo AIH provides a comprehensive, context-specific framework for sustainable pest management. It integrates IPM strategies, institutional coordination, health and safety safeguards, and participatory engagement to reduce pest losses while protecting human health and the environment.

The plan is aligned with AfDB's ISS, World Bank ESS3, and FAO IPM principles, ensuring compliance with international best practices and national regulatory requirements. By embedding pest surveillance, cultural and biological controls, regulated pesticide use, and post-harvest management, the PMP enhances productivity, food safety, and resilience.

Budgeting and financing mechanisms guarantee sustainability, while stakeholder engagement promotes ownership, equity, and transparency. Monitoring and evaluation systems institutionalize adaptive management, enabling rapid adjustments based on evidence.

The PMP thus positions the AIH not merely as a compliance tool but as a model of climate-smart, sustainable agriculture. It strengthens farmer capacity, reduces reliance on hazardous chemicals, improves health and environmental outcomes, and secures market competitiveness. By harmonizing technical, financial, institutional, and social dimensions, the PMP ensures that the AIH can deliver on its dual goals of agro-industrial growth and sustainable development.

1 INTRODUCTION

1.1 Background

This Pest Management Plan (PMP) is designed to prevent, control, and monitor pest risks associated with the proposed Agro-industrial Hub (AIH) at Adiabo, Odukpani Local Government Area of Cross River State throughout its lifecycle: pre-construction, construction, operation, and decommissioning. It emphasizes Integrated Pest Management (IPM) to minimize reliance on chemical pesticides, protect human health, preserve environmental integrity, and comply with national (Nigeria) and international (AfDB, WHO, FAO) standards. The plan aligns with the African Development Bank's Integrated Safeguards System (ISS, 2023), particularly Operational Safeguard 3 on resource efficiency and pollution prevention, the World Bank's Environmental and Social Standard 3 (ESS3) on resource efficiency and pollution prevention, and the FAO's Integrated Pest Management (IPM) principles, which promote ecological balance and reduced chemical dependency. This ensures that pest control measures meet international benchmarks while remaining practical for local implementation.

The proposed Agro-industrial Hub located in Adiabo, Odukpani Local Government Area of Cross River state is part of the Special Agro-industrial Processing Zones (SAPZs), a Federal Government of Nigeria's initiative driven by the Federal Ministry of Agriculture and Food Security (FMAFS) in collaboration with state governments, development partners, relevant federal ministries, departments and agencies (MDAs), and private investors and funded by the African Development Bank (AfDB), Islamic Development Bank (IsDB), International Fund for Agricultural Development (IFAD), and contributions from the Federal and State Governments. The 130ha land proposed for the AIH is a communal land of the Adiabo Clan donated to the Government of Cross River State. The AIH seeks to integrate agricultural production, value addition, and market access in one location, thereby reducing post-harvest losses, boosting export readiness, and generating employment opportunities.

While the AIH will drive economic growth and rural employment, its scale and diversity of activities inherently create conditions conducive to pest problems if unmanaged. These include:

- i Construction-phase risks: clearing of vegetation, earthworks, standing water from drainage works, and temporary camps all increase vector breeding and rodent harbourage.
- ii Operational risks: movement and storage of large volumes of agricultural raw materials, presence of food residues, organic waste, and packaging materials are all prime attractants for storage insects, rodents and molds.
- iii Landscape and buffer zone risks: extensive landscaped areas and storm-water drainage features, if poorly managed, can provide breeding sites for mosquitoes and invasive plant species.
- iv Interface with local communities: increased human and vehicle movement can introduce or spread pests and disease vectors beyond the project boundaries.

Uncontrolled pest infestations can result in:

- i Economic loss due to damage or contamination of stored goods, increased spoilage, and loss of market value.
- ii Public health impacts such as food-borne disease outbreaks, increased incidence of malaria or other vector-borne diseases, and allergic reactions in workers.
- iii Environmental degradation due to indiscriminate or excessive pesticide use (soil and water contamination, harm to non-target species, biodiversity loss).
- iv Negative perceptions by regulators, financiers and communities, jeopardising the AIH's "green" credentials and AfDB's Operational Safeguard compliance.

Given these realities, an explicit, stand-alone Pest Management Plan (PMP) is required to complement the Environmental and Social Impact Assessment (ESIA) and other management plans (Biodiversity Management Plan, Labour Management Plan, Waste Management Plan, etc.). The PMP is designed to:

- i Provide a framework for Integrated Pest Management (IPM) tailored to the AIH's facilities and activities.
- ii Establish clear responsibilities and resources for pest prevention, monitoring and control across all phases of the project.
- iii Minimise reliance on chemical pesticides and promote environmentally friendly, cost-effective alternatives wherever feasible.
- iv Protect the health and safety of workers, contractors, and surrounding communities.
- v Ensure compliance with Nigerian law, FMEnv and NAFDAC pesticide regulations, and AfDB's Operational Safeguard 3 on resource efficiency and pollution prevention.

This PMP is therefore both a risk-management instrument and a capacity-building tool. It brings together best practice from FAO/WHO guidance on IPM, Nigerian regulatory requirements, and lessons learned from similar agro-industrial hubs. When implemented, it will provide a structured, auditable approach to pest control that can be updated as the project evolves.

1.2 Objectives of the Pest Management Plan (PMP)

1. Reduce reliance on Highly Hazardous Pesticides (HHPs): Phase out the use of WHO Class Ia/Ib pesticides within five years and replace them with safer, NAFDAC-approved alternatives, thereby lowering environmental and health risks.
2. Promote Integrated Pest Management (IPM) adoption: Ensure that at least 70% of farmers linked to the AIH adopt IPM practices (e.g., resistant varieties, biological control, crop rotation, and threshold-based interventions) within three years of project operation.
3. Strengthen pest surveillance and monitoring systems: Establish a digital, GIS-enabled pest and disease surveillance platform with functional field scouting, community reporting, and hotspot mapping within two years of project implementation.
4. Enhance farmer and extension worker capacity: Train a minimum of 5,000 farmers and extension officers on IPM principles, safe pesticide use, and pest surveillance through Farmer Field Schools and Training-of-Trainers programs within three years.

5. Improve pesticide handling, storage, and disposal practices: Set up centralized safe pesticide storage facilities and implement container collection and disposal systems compliant with NESREA regulations within two years.
6. Promote environmental and occupational safety: Reduce incidences of pesticide-related health hazards among AIH farmers and workers by 50% within four years, through protective equipment provision, safety campaigns, and regulatory compliance.
7. Foster institutional coordination and policy alignment: Operationalize a multi-stakeholder pest management coordination committee linking government agencies, private investors, and farmer associations by year one of project implementation.

1.3 Purpose and Scope of the PMP

This Pests Management Plan (PMP) aims to safeguard the agricultural productivity and environmental integrity of the AIH project by providing a structured approach to pest management using Integrated Pest Management (IPM) principles.

The scope of PMP covers all categories of crops grown in AIH project (cassava, yam, maize, legumes, rice), and in alignment with SAPZ's ambition to industrialize agro-processing, the plan will integrate ecological protection, health standards, and regulatory compliance and shall remain a working document throughout the lifespan of the project.

1.4 Rationale for Pest Management Plan

It explains why a Pest Management Plan is necessary in line with international best practices and donor requirements (e.g., African Development Bank (AfDB) operational safeguards 3, World Bank ESS 3). This part stresses that uncontrolled pesticide use has ecological, human health, and environmental implications. Hence, the need for integrated and sustainable approaches.

1.5 Environmental and Social Consequences of Pest Management Practices

Historically, farmers in Cross River State including those that will be supplying the AIH have relied heavily on broad-spectrum chemical pesticides to control pests on cocoa, cassava, rice, yam, maize and legumes. While these products provide short-term suppression, unstructured and repeated use has produced significant environmental and social consequences. Run-off from treated fields and improper disposal of pesticide containers have contaminated streams and wetlands that local communities depend upon for fishing and domestic water. Beneficial organisms such as pollinators, soil micro-flora and natural predators of crop pests have been decimated, reducing ecosystem resilience and increasing pest resurgence.

On the social side, farmers and farm workers—particularly women and youth, who make up a large share of the labour force—face occupational exposure through inhalation, dermal contact and pesticide drift. Lack of personal protective equipment (PPE), inadequate training and the use of obsolete or unlabelled products heighten these risks. Chronic exposure can lead to long-term health problems and residues in food, eroding consumer confidence and jeopardising public health.

Without a structured plan, these practices compound ecological risks, occupational hazards and food-chain contamination. The Pest Management Plan therefore seeks to reverse these trends by promoting integrated pest management (IPM); restricting or phasing out highly hazardous pesticides (HHPs); enforcing proper handling, storage and disposal of chemicals; establishing unsprayed buffer zones along watercourses; and strengthening training, PPE provision and medical surveillance for workers and communities. By doing so, it safeguards the environment, protects vulnerable groups and sustains the resource base on which the AIH depends.

1.6 Potential Impacts of Pest and Pesticide Management on Project Activities

Pest pressure on the AIH's key value chains—cocoa, cassava, rice, yam, maize and legumes—can reduce yields anywhere from 5 to 40 percent if left unmanaged. Such losses would directly undermine the AIH's processing capacity, supply reliability and revenue projections. Post-harvest infestations can also lead to quality defects and mycotoxin contamination, jeopardising HACCP, ISO 22000 and NAFDAC certifications required for local and export markets. Conversely, indiscriminate or excessive pesticide use brings its own risks. Residue exceedances can breach AfDB ISS Operational Safeguard 3, national food-safety limits and international buyer standards, closing off lucrative markets. It can also lead to pest resistance, driving up control costs, and cause health and safety incidents that increase insurance premiums and damage the project's reputation with communities and regulators.

The PMP therefore balances effective pest suppression with environmental, health and safety safeguards. Through routine surveillance, economic threshold-based interventions, adoption of biological and cultural controls, and a restricted list of approved pesticides, the plan ensures that pest management supports rather than undermines the AIH's objectives. This integrated approach protects crop yields and quality, maintains market credibility, and minimises environmental and social risks—delivering a sustainable foundation for the project's long-term success.

2 PROJECT DESCRIPTION

2.1 Proposed Project Location

The proposed AIH in Adiabo, Odukpani Local Government Area of Cross River State is located along Tinapa-Adiabo road at latitude $5^{\circ} 4'2.88''\text{N}$; longitude $8^{\circ}19'17.76''\text{E}$, covering an approximately 130 hectares of land (**Error! Reference source not found.**). The project site bordered southward at latitude $5^{\circ} 3'52.81''\text{N}$; longitude $8^{\circ}19'25.05''\text{E}$, a distance of 200m from government secondary school Adiabo while northward, the project area border at latitude $5^{\circ} 4'4.07''\text{N}$; longitude $8^{\circ}19'33.06''\text{E}$ adjacent Banga Camp. At extreme north-western end, the project site bordered at latitude $5^{\circ} 4'38.92''\text{N}$; longitude $8^{\circ}19'5.11''\text{E}$ close to stationaries materials while at the extreme south-western end, the proposed site bordered at latitude $5^{\circ} 4'6.10''\text{N}$; longitude $8^{\circ}18'41.25''\text{E}$ (**Error! Reference source not found.**). A tributary of the Cross River traverses the project site before joining the Cross River at latitude $5^{\circ} 3'29.64''\text{N}$; longitude $8^{\circ}18'20.14''\text{E}$. Major landmarks near the project site include: Government Secondary School Adiabo located 200m southward, Adiabo townhall located 600m south of the project site, Tinapa water park at 1,700m southward, Banga Camp located 250m northward, Marygold International boarding school located 880m northward, Adiabo power sub-station located 1500m northward. The distance from Tinapa junction to the project site is approximately 3,000 metres.

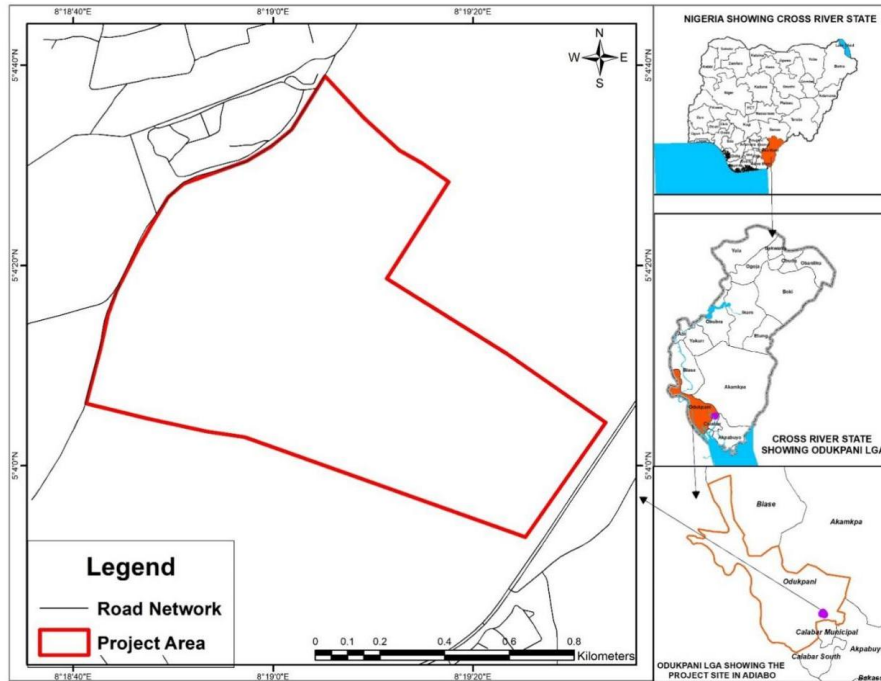


Figure 1: Location Map of the Proposed Agro-Industrial Hub in Adiabo, Odukpani LGA.



Figure 2: Satellite Imagery of the proposed AIH at Adiabo Showing Major Landmarks

1.2.2 Project Layout

The proposed Agro-Industrial Hub (AIH) is being developed through a Design, Build and Operate (DBO) / site and services model. It is planned to sit on a 130 ha of land (**Error! Reference source not found.**). The proposed AIH is planned to provide common infrastructure and facilities to the expected agro-industries of various scales, ranging from small to medium and large which will be established, owned and operated by prospective investors. Based on the value chain needs of the AIH, the site layout is developed (Figure 3 and Figure 4). The required facilities are as shown in **Error! Reference source not found.**

1.2.3 Components of the Agro-industrial Hub (AIH) at Adiabo

The proposed AIH will include civil engineering infrastructure such as office buildings, training centres, general services fencing, internal access roads/parking, drainage, power supply, water, and sewerage, effluent management, health, and safety. The facilities with specialized services in relation to the PMP will include quarantine facilities, quality control point, certification centres, laboratory, crop processing and storage facilities and breeding centres. Other facilities will include business support services (administrative knowledge/ ICT/procurement /employment centres) and other activities to implement the PMP.

The proposed AIH will have common on-site and off-site infrastructures and facilities for the use of all tenants and operators. These will include access and internal roads and drainage, power and water supplies, solid and liquid waste management facilities, warehousing, market, etc. The industries will be built, owned and operated by prospective investors. The details of the of the proposed infrastructure are presented in sections following.



Figure 3: Proposed AIH Layout

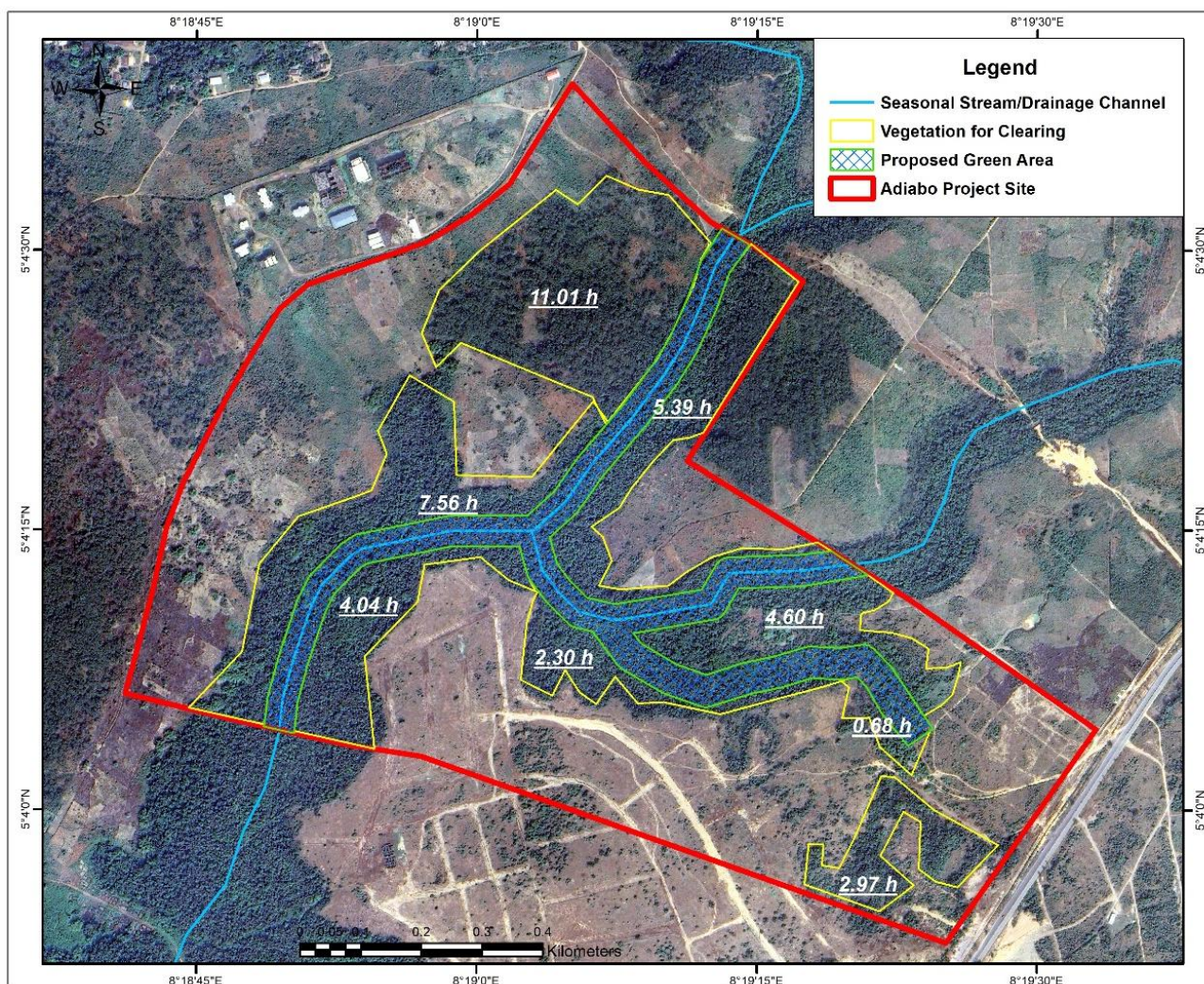


Figure 4: The AIH site showing the area (in yellow) of vegetation to be cleared and conserved (in green)

Table 1: Facilities and components in the proposed AIH

Description	Area (SqM)
Perimeter Fence	1,150
Gate /gate house	500
Security outpost	500
Commodity service Centre	10,000
Commodity processing Centre	20,000
Industrial / Employment zone	100,000
Truck Park	30,000
Community vocational Centre	10,000
Residential area	50,000
Water facility (boreholes, overhead tanks/steel towers & reticulation)	1,000
Water treatment plant	1,000
Power facility	1,000

Description	Area (SqM)
Storage warehouses	20,000
Cold storages (meat etc.)	10,000
Fuel station	5,000
Solid waste management plant	2,000
Sewage and effluent treatment plant	4,000
Fire station	1,000
Admin. Block	2,000
Commodity loading and unloading bays	10,000
Veterinary clinics	1,000
Health centre	1,000
Market	20,000
Recreational	10,000
QA&QC lab	1,000
Knowledge centre	3,000
Procurement centre	2,000
Agric equipment centre	10,000
Bank + ATM services	2,000
Small scale industrial zone	200,000
Medium scale industrial zone	200,000
Large scale industrial zone	200,000
Future development area	175,000
Green area	125,000
	1,328,000

On-Site Infrastructure and Facilities Planning

On the basis of function and facilities required for the AIH, on-site infrastructure is planned and describe based on its site provision (as indicated in **Error! Reference source not found.**, facilities design details (**Error! Reference source not found.** and component capacity and lifespan details (**Error! Reference source not found.**..

Table 2: AIH Site provisions

SN	Description	Remarks
1	Land Development	Site grading works will only be for the road and general infrastructure area, to enhance economy and environmental considerations. The vegetation along the water courses, accounting for about 12.5 ha of the proposed site (Error! Reference source not found. shall be conserved green to retain the carbon sequestration capacity of the site. The total area that would be cleared of vegetation is 37.94 ha. The remaining 80 ha of the available 117.5 ha has crops that would be harvested before construction. The trees in this portion of the land will be left, as much as possible, standing.

2	Boundary wall and fencing	A wall fence to surround the zone is planned. This will enhance the security of the project. The total approximated length of the fence is 4.6 km. Trees shall be planted at 10 m interval along the internal fence line to enhance the carbon sequestration capacity of the facility and compensate for the 164,720.23.55 m ³ of biomass that will be removed during site clearing. Approximately, 170,000 pieces of concrete blocks will be used to erect the perimeter fence.
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Table 3: Facility Design Details

Design Details of AIH	
Area in Ha	130 ha
Time period	
Design	4 Months
Construction	18 Months
O&M (Including DLP)	60 Months
Internal Road	Length: 5500 Rmt ROW: 18m wide, with solar street lights and channel kerbs.
Drain	Length: 3804 Rmt - ranging from 500mm x 500mm to 1000mm x 1000mm
Electrical	
Power Source	0.2 km to the substation, 33 kV line along the plot boundary
Power Demand	13MVA
Distribution length	3.8 km
Sub-station	Compact substation of 1000 kVA
Water	
Source	Ground Water (Unless state brings surface water to the site)
Demand	1500 KLD
borewell	2 Nos
Storage	1000 KLD Capacity
Distribution	3.8 Km of HDPE pipe ranging from 225 mm to 280 mm
Wastewater	
Generation	1550 KLD
STP	1000 KLD
Conveyance	3.8 Km of HDPE pipe ranging from 225 mm to 280 mm
Buildings	1. Administrative Block + Research and Development + Disaster Management - 400 Sqm
Fire station	75 Sqm - with Shed for fire tender (Does not include cost of fire tender)
Public Toilet	60 Sqm - 8 WCs x 2
Gate & Gatehouse	1 Nos
Boundary wall	4600 Rmt - Chain Link Fencing
Access Roads	Since the Plot is next to the Highway, Access Road has not been considered

Table 4: AIH component capacity and lifespan details

AIH Project Components		
Component	Capacity / Specification	Design Life (Years)
Internal Roads	5500 Rmt, Flexible pavement, 18m ROW with solar street lights	20
Drains	12804 Rmt, RCC rectangular, 600 mm wide	30
Power Demand	Peak Load 23 MVA (Installed capacity 500 KVA x 2)	N/A
Substation	Compact substation (1000 KVA)	20
Electrical Distribution	13.8 km	20
Borewells	2 Nos, Depth 200 m, Yield 65 m ³ /hr	20
Storage Tanks	500 KLD, Ground-level RCC tanks	35
HDPE Distribution Pipes	13.8 km, PN 10, 225–280 mm diameter	25–50
Wastewater Generation	1750 KLD, Domestic + Industrial mix	N/A
STP Type	MBBR technology	
STP Capacity	500 KLD	
STP Lifespan (Civil)		35
STP Lifespan (Mechanical)		15
Sewer Network	9.8 km, HDPE 225–280 mm diameter	25–50
Admin / R&D / Other Buildings	RCC framed, GI roofing	50–60
Public Toilets	60 sqm, 16 WCs	30–40
Fire Station	75 sqm, RCC, 24x7 manned	40–50
Gate & Gatehouse	RCC structure	40–50
Chain Link Fencing	4600 Rmt, 2m height, steel posts with concrete foundation	15–20

1.2.4 The Need for the Project

The need for the proposed AIH stems from the existence of constraints on crop value chains in Cross River State as summarized in

Table 2.

A large percentage of households in rural areas of Nigeria are dependent on subsistent farming for survival, with majority of them being smallholder farmers. While they have the landmass as compared to the cities, such factors as youth migration, limited access to funding, infrastructure and technology among others are causing an increasing decline in food security. A solution to these food security challenges will increase agricultural output, create jobs and improve livelihoods for its citizens. Another benefit of this strategy is the creation of job opportunities, reduced cost of living, diversification of the Nation's economy and generally enhancing sustainable development.

The agricultural sector of Nigeria remains largely untapped and poses bright prospects for the her to tap into for the country’s general development. The establishment of SAPZs in Nigeria (Cross River State) will boost the structural transformation of the economy by providing opportunities for public and private sector investment in agriculture, and when fully operational, the SAPZs will enhance national food and nutritional security, optimize the export of value-added agricultural commodities and improve the quality of livelihoods through wealth creation for rural farming communities.

Table 2: Crop value chain constraints in Cross River State

Production Constraints	Marketing Constraints	Processing Constraints
Low yield	Inadequate access to appropriate packaging material	Inappropriate processing technologies particularly among small-scale millers
Pest and diseases which limit optimum yield in most of the production areas of state;	Price fluctuation	Poor equipment maintenance support by dealers, shortages and high cost of equipment and spares
Limited access to information from extension service.	Inadequate sources of finance	Erratic power supply and increased cost of fuel
Inadequate certified inputs such as seeds, fertilizer and herbicides etc	Small traders have limited storage capacity and thus are committed to a continuous cycle of buying and selling.	Unreliable supply of produce

2.1 Benefits of the Project

The SAPZ initiative will diversify the nation’s economy, creating another major avenue for revenue generation out of the agricultural sector. The success of this project will improve food security in Cross River state, improve inter-state and largely inter-country export opportunities and in turn boost the economy of the state and largely that of the nation while creating job opportunities, improved livelihoods and ultimately, the reduction of poverty.

2.1.1 Socioeconomic Benefits of the Project

In line with the efforts of the federal government of Nigeria in the diversification of the economy via vehicles of promoting the non-crude oil export sector, the SAPZ program presents similar objectives, which aligns and complements the activities of the government. The project will further complement the drive of the government. Agricultural development remains one of the most viable sectors in lifting people out of poverty and creating sustainable economic growth and shared prosperity. Furthermore, agro-industrial processing creates an accelerated increase in farmers' productivity; this, in turn, helps to reduce post-harvest losses, market access creation and deepening of the crop value chain.

The current agricultural promotion drives of the federal government of Nigeria, when combined with development efforts of the private sector, will create a multiplier effect in bringing about the sustainable development goals of food security, economic development and shared prosperity. The project, when implemented, will bring about the rapid economic development of the host communities and reduce rural-urban migration.

The project will go a long way in creating market access for the target crops and other agricultural produce; this will effectively reduce the prevalent post-harvest losses, which characterized smallholder farming in Nigeria. The creation of out-grower scheme would ensure the training of thousands of farmers on Good Agricultural Practices, modern Agronomy, post-harvest handling etc.; this knowledge transfer will translate to capacity building for the farmers in the programme to improved productivity. The creation of jobs along the value chain of the target crops and employment is also expected to boost agricultural and economic productivity in the area. In conclusion, through the SAPZ business activities, the much-needed foreign exchange, more revenues will be generated for the government to boost government spending; this is done through various payments such as taxes, tariffs to the federal and state agencies tasked with such collections.

The benefits of the SAPZ program are enormous to agricultural development in Nigeria. However, the specific benefits have been categorized into three namely:

2.1.2 Benefits for the Government

The project will improve the business environment and increase the ease of doing business in the various project sites. This will increase trust between the government and investors and encourage more private investors' involvement.

2.1.3 Benefits for the Community

Security: The project will improve the internal security of the community and will protect assets.

2.1.4 Financial and social inclusion: The project will provide access to financial services to agricultural value chain actors within the project communities. Also, improve the Socioeconomic status of the value chain actors within the project sites.

2.1.5 Road Access: The project intervention will develop infrastructure, especially road access to the relevant facility for easy transportation of produce and people.

Human capacity development in specific skills and availability of technical personnel: The project will provide training for a specific group of people, especially youths and women, on specific skills.

2.1.6 Market accessibility:

- The project will create a ready market that is easily accessible to the relevant actors.
- The project will create mass employment opportunities for the youths and women within the project sites. This will create a ripple effect in the neighbouring communities. Thus, improving the local economy.
- Community development through CSR programme by the private sector.
- Reduction of post-harvest losses due to short distance to market and increase in value addition.

2.1.7 Benefits for the Investors

The project will increase production efficiency by reducing the costs of production. This will be achieved through State policies of low-cost land-lease, low-cost labour, tax waiver for up to a maximum of 7 years (100%), and Corporate Social Responsibility credits for tax reduction after seven years within the project sites.

The cost of infrastructure maintenance is low as it is a shared facility, which reduces the cost of operations within the project sites.

The infrastructures built at the project sites are of world-class standards, and it will be easy to implement food safety standards such as HACCP, ISO 22000, NAFDAC, SON, and other international certifications for processing activities.

2.1.8 Revenue Drivers

The expected revenue drivers of the proposed AIH are presented in Table 3.

Table 3: Revenue Sources

Revenue sources	Details
Revenue from developed plots of the AIH – industrial, residential, commercial and social sections	<ul style="list-style-type: none"> ➤ The AIH shall actively market the multi-formatted developed plots for mixed-use like industrial, commercial, residential and social areas. ➤ The management of the AIH would enter into a long-term leasehold/short term lease/yearly lease/monthly rental with occupant industries, residential, commercial, and institutional areas users; and ➤ Income generation from undeveloped land long-term leasehold, developed land short-term lease, developed yearly land lease, developed land monthly lease rentals.
Revenue from built-up spaces – industrial, residential, commercial and social sections	<ul style="list-style-type: none"> ➤ The AIH shall also actively market the multi-formatted built-up spaces for mixed-use like industrial, commercial, residential and social areas. ➤ The management of the AIH would enter into long-term leasehold/short-term lease/monthly lease rental for the usage of the built-up spaces with the occupant industries, commercial, residential, and institutional area users; and ➤ Income generation from built-up space - long-term leasehold, built-up space – short term lease, built-up space – monthly lease rentals.

Revenue sources	Details
Revenue from facility management	<ul style="list-style-type: none"> ➤ There will be M & E on AIH utilities and infrastructure facilities to ensure delivery of design standards in service are given paramount importance. The AIH operating principles shall need to adhere to the highest standards of workers safety, hygiene, and environment and shall need to conform with various national and international standards; and ➤ The income from facility management.
Revenue from operations of specialized agriculture infrastructure facilities	<ul style="list-style-type: none"> ➤ Income from operations of specialized agro infrastructure within the AIH covering warehoused, procurement centres, packing & labelling, grading & sorting, quality assurance and quality control laboratories, administrative building, etc.
Income from energy supply	<ul style="list-style-type: none"> ➤ Income from energy supplied to operators and service providers within the AIH. The primary source of power is through external power supply from the national grid, and also provision from standby power generation units is provided.
Revenue from the water supply	<ul style="list-style-type: none"> ➤ Income from water fees charged on usage by operators
Margins from commercial and common social infrastructure	<ul style="list-style-type: none"> ➤ Income from shared services and infrastructure
Income from business support	<ul style="list-style-type: none"> ➤ Income earned from various business support services
Income from business facilitation	<ul style="list-style-type: none"> ➤ Income from various business facilitation, link-ups, produce marketing support, branding, etc.
Margin from auxiliary services	<ul style="list-style-type: none"> ➤ Income from food courts, restaurants, banks, vending machines, etc.
Revenue from advertisement	<ul style="list-style-type: none"> ➤ Revenue from advertisements, billboards, trade shows, etc.
Truck parking	<ul style="list-style-type: none"> ➤ Revenue from vehicle and truck parking lots, loading bays, etc.
Weighbridge	<ul style="list-style-type: none"> ➤ Fees charged on weighing of trucks and lorries based on weight

2.2 Value of the Project

Table 4 and Table 5 summarize the potential value chains for the three major crops for the CR-SAPZ, cassava, cocoa and rice, respectively.

Table 4: Potential Cassava Value Chain

Potential value	Details
Potentials for value addition	<ul style="list-style-type: none"> ✓ Increase yields from 9 ton to 30 mt / ha ✓ Availability of improved varieties ✓ Production/processing of industrial products such as ethanol, starch, etc. ✓ Import substitution potentials ✓ Availability of improved processing techniques
Market potentials	<ul style="list-style-type: none"> ✓ There is an opportunity for grouped sales by organized smallholder producers or cooperatives upon meeting the off-taker requirement, ✓ Stable price

Potential value	Details
	<ul style="list-style-type: none"> ✓ High industrial demand ✓ Export potential of cassava by-products
Potential for pro-poor growth Gender relevance	<ul style="list-style-type: none"> ✓ Women farmers are actively involved in cassava production ✓ Marketing of cassava related products are dominated by women ✓ Retail selling is mainly female business ✓ Small scale processing is dominated by women ✓ Industrial processing is dominated by men
Job creation in downstream sectors	<ul style="list-style-type: none"> ✓ High potential in small-scale processing ✓ Export ✓ High potential to attract FDI ✓ Transportation/logistics ✓ Artisanal and industrial processing will generate significant number of jobs

Table 5: Potential Cocoa & Rice Value Chains

Potential value	Details
Potentials for value addition	<ul style="list-style-type: none"> ✓ Improved quality of processed cocoa beans & milled rice, especially reduction of impurities and stones by better harvesting and processing techniques ✓ Innovations for farm machinery/extension services ✓ Soil testing for optimum fertilizer application ✓ Training on GAP (including fertilizers, herbicides, etc.) ✓ Promotion of agro machinery service providers ✓ Capacity building for machinery and equipment operators (power tiller, mills, etc.) ✓ Linkages to effective financial services/literacy trainings/management ✓ Improved quality of certified seeds ✓ Strengthened linkages among the value chain actors ✓ Availability of credible market information
Market potentials	<ul style="list-style-type: none"> ✓ Huge deficit demand and supply of rice in Nigeria ✓ Availability of off-takers all over the country ✓ Import substitution potentials
Potential for pro-poor growth Gender relevance	<ul style="list-style-type: none"> ✓ Women are actively involved in processing and production ✓ Marketing of rice paddy and cocoa beans is predominantly carried out by men and youth ✓ Retail selling is mainly female business ✓ Small scale processing is dominated by women
Job creation in downstream sectors	<ul style="list-style-type: none"> ✓ High potential to attract FDI ✓ Transportation/logistics ✓ Seed breeders and multipliers ✓ Small and large-scale production, marketing and processing will generate significant number of jobs
Natural endowments	<ul style="list-style-type: none"> ✓ Favorable climatic condition such as low temperature and optimum relative humidity during large part of the year

Potential value	Details
Profitability	✓ Highly profitable upon meeting the requirement of the buyers and off-takers

2.3 Envisaged Sustainability

Sustainability is the ability of a development project to maintain or expand a flow of benefits at a specified level for a long period after project inputs have ceased. The concept of sustainability means different things to different activities, organizations and developments. Specifically, for the project, sustainability means, ensuring the project continues to maintain its operations, provide its services and deliver its long-term benefits during implementation and projected life span. The sustainability of the proposed project is evaluated and described below using the following dimensions/ factors, namely: environmental, social, economic and technical considerations.

To ensure long-term sustainability, the AIH project integrates advanced pest management strategies that go beyond productivity to safeguard public health, ecosystems, and compliance with national and international safeguards. Specific sustainability measures include:

1. Reduced Pesticide Dependency

- a. Adoption of Integrated Pest Management (IPM)-first principles, where cultural, biological, and mechanical practices take precedence over chemical use.
- b. Promotion of resistant crop varieties, crop rotation, intercropping, and hermetic storage to suppress pest incidence naturally.
- c. Restriction to NAFDAC-approved, low-toxicity products, with clear exclusion of WHO Class Ia/Ib actives and phased reduction of Class II chemicals.
- d. Threshold-based interventions guided by pest scouting and digital dashboards, ensuring pesticides are only applied when strictly necessary.

2. Strengthened IPM Adoption

- a. Establishment of Farmer Field Schools (FFS) and Training-of-Trainers (ToT) programs to institutionalize IPM knowledge within farming communities.
- b. Deployment of youth IPM scouts for community-level surveillance, promoting early detection and timely interventions.
- c. Integration of biological control agents (e.g., *Trichogramma*, neem-based botanicals) into farmer toolkits, reducing reliance on synthetic inputs.
- d. Ongoing monitoring and feedback systems to adapt IPM measures to local pest dynamics and climate variability.

3. Safe Disposal and Stewardship Practices

- a. Mandatory triple-rinsing and puncturing of empty pesticide containers, followed by return to approved recycling or disposal channels.
- b. Establishment of secure storage facilities at AIH, equipped with ventilation, spill kits, and fire extinguishers.
- c. Compliance with NESREA hazardous-waste regulations and Good International Industry Practices (GIIP) for transport, storage, and disposal.
- d. Community-awareness campaigns to prevent unsafe reuse of containers and promote collective responsibility for waste management.

By embedding these measures into the AIH operations, the project not only reduces environmental and health risks but also builds resilient local pest management systems that are socially acceptable, economically viable, and technically replicable across similar agro-industrial hubs.

2.3.1 Social Desirability

The AIH project prioritizes her stakeholders' perception, especially the acceptance of the hosts communities. Stakeholders' Engagement and Grievance Redress Mechanisms have been established throughout the project life cycle to address the needs of stakeholders. The engagement process already commenced from the scoping stage all through the field data gathering exercise to the public consultation held with stakeholders on the outcome of the ESIA. It is envisaged that the effective implementation of the E&S safeguards instruments, including the Livelihood Restoration Plan, will ensure social desirability of the project. Additional measures to ensure social sustainability of the project, will include the following:

Inclusion of vulnerable groups such as elderly people, female heads of household, children and youth, racial and ethnic minorities, displaced persons, women and girls etc.

Implementation of Corporate Social Responsibility (CSR) programmes targeted at improving Socioeconomic and health status in project affected communities will be embarked upon.

Employment of as many local inhabitants of the host communities as possible during all phases of the project. Contractor's employment policy shall give preference to indigenes of these communities in a bid to ensure that they benefit directly from the project.

Promote training, mentorship and development opportunities to prepare talented employees for successful succession

2.3.2 Economic Viability

The economic viability of the proposed AIH project is based on the fact that it will eliminate agricultural and agro-industrial constrains, improve productivity, and therefore Return on

Investment (ROI), improving exports to other states and outside the country as well. Additionally, the expansion of local markets is imminent with the inception of the project. The AIH project is designed to create both direct and indirect labour, skilled and unskilled workers for both indigenes and non-indigenes, which will in turn improve livelihood of the people and bring economic development to the state and the country at large.

2.1 Development Options with Pest Management Implications

No Project Option

If the project is not implemented, existing pest management challenges in Cross River State will persist. Farmers will continue to rely heavily on unstructured chemical pesticide use, leading to:

- a. Continued yield losses of 15-40% in cocoa, cassava, rice, maize, yam, and legumes due to pest and disease infestations.
- b. Uncontrolled pesticide misuse, resulting in soil and water contamination, harm to pollinators, and increased pest resistance.
- c. Lack of structured surveillance and Integrated Pest Management (IPM) support, leaving smallholder farmers vulnerable.

Implication: Pest pressure remains high with escalating environmental and social risks.

Delayed Project Option

Postponing the project would mean delayed introduction of structured IPM systems, training, and surveillance infrastructure. In the interim:

- a. Farmers will remain dependent on hazardous and costly chemical pesticides without access to safer alternatives.
- b. Pest infestations may intensify due to climate variability and expanding resistant pest populations.
- c. Opportunities to implement sustainable container disposal, biological control measures, and digital monitoring systems will be lost or deferred.

Implication: Pest-related crop and economic losses continue unchecked, increasing future control costs and jeopardizing food security.

Immediate Project Implementation

Implementing the AIH project as planned will require proactive pest and pesticide management to protect crop supply chains and ensure compliance with AfDB OS and NAFDAC standards.

- a. Establishment of IPM systems (scouting, threshold-based interventions, biological controls, and restricted pesticide lists).
- b. Deployment of surveillance and GIS-based monitoring tools for early detection and containment of outbreaks.
- c. Adoption of safe handling and disposal practices for pesticides to prevent community health and environmental risks.

Implication: While pest risks are inherent, they can be effectively managed through structured IPM systems, capacity building, and regulatory oversight — turning pest management into a sustainability advantage.

2.5 Project Site Alternatives – Pest Management Considerations for AIH

The selection of an appropriate site for the Agro-Industrial Hub (AIH) was guided not only by infrastructural, environmental, and socioeconomic criteria but also by the pest management implications critical to the Pest Management Plan (PMP). Using Geographic Information Systems (GIS) and Multi-Criteria Analysis (MCA), four alternative locations were assessed: Mbarakom (Akamkpa LGA), Adiabo (Odukpani LGA), Ekpri Iking (Bakassi LGA), and Ikot Mbakara (Akpabuyo LGA).

1. Mbarakom (Akamkpa LGA)

- Limitations: Poor Road access and distance from markets hinder timely pest surveillance and IPM interventions. The rugged terrain and erosion risk complicate deployment of pest monitoring tools.
- Pest Implication: Delays in movement of extension staff and pest scouts would lead to late responses, increasing risk of outbreaks and post-harvest losses.

2. Ekpri Iking (Bakassi LGA)

- Limitations: Low-lying topography with high flood risk makes it unsuitable for sustained agriculture. Flooding increases pest pressures (rodents, fungal diseases) and complicates chemical storage.
- Pest Implication: Recurrent waterlogging would heighten crop vulnerability, foster pest and disease build-up, and compromise safe pesticide storage and disposal.

3. Ikot Mbakara (Akpabuyo LGA)

- Limitations: While moderately suitable in terms of accessibility, the site is constrained by periodic flooding and distance from smallholder production zones.
- Pest Implication: Pest monitoring would be fragmented, and vulnerability maps show higher risk of pest spread due to moisture-related infestations.

4. Adiabo (Odukpani LGA) – Preferred Site

- Strengths: Located near major roads and markets, with moderate topography and favorable land-use profile. Proximity to smallholder farms ensures integration of farmer pest data into AIH surveillance systems.
- Pest Implication: Offers the best environment for a comprehensive IPM program. The site allows effective deployment of GIS-based surveillance, NDVI/VCI pest vulnerability mapping, farmer field schools, and safe pesticide storage/disposal infrastructure.
- Outcome: Ensures timely detection, prevention, and management of cocoa, rice, cassava, yam, maize, and legume pests — the core crops covered under the PMP.

2.6 Description of AIH Crops and Pests

The Agro-industrial Hub (AIH) at Adiabo, Odukpani Local Government Area of Cross River State will process and market produce from hundreds of smallholder farmers. The main crops subject to pest or vector control under this PMP are cocoa, rice, cassava, yam, maize and legumes (Table 9). Each of these crops faces well-known pests in the agro-ecological zone of southern Cross River. The table below profiles the crops, typical pests/vectors and the stage of the value chain at which pest control is most critical. Illustrative photographs and maps of the AIH location are included in the annex to make the plan visually grounded.

Table 9: AIH Adiabo Crops, Key Pests/Vectors and Control Points

Crop (AIH focus)	Typical pests/vectors in Cross River context	Critical control stage (farm/AIH)
Cocoa (<i>Theobroma cacao</i>)	Cocoa mirids (<i>Sahlbergella</i> spp.), capsids, black pod disease (<i>Phytophthora</i> spp.)	Farm: pod development and harvest; AIH: storage hygiene
Rice (<i>Oryza sativa</i>)	African rice gall midge, stalk borers, rice blast disease	Farm: nursery to tillering; AIH: paddy storage
Cassava (<i>Manihot esculenta</i>)	Cassava green mite, cassava mealybug, bacterial blight	Farm: vegetative growth; AIH: root storage and transport
Yam (<i>Dioscorea</i> spp.)	Yam beetles, scale insects, anthracnose	Farm: mound planting to tuber bulking; AIH: tuber handling
Maize (<i>Zea mays</i>)	Fall armyworm (<i>Spodoptera frugiperda</i>), stem borers, maize streak virus	Farm: seedling to tasseling; AIH: grain storage
Legumes (<i>Cowpea, soybean</i>)	Pod borers, aphids, bruchids in storage	Farm: flowering to pod fill; AIH: bagged storage

Considering pest management requirements alongside physical and economic criteria, Adiabo was selected as the optimal site. It provides the necessary balance between accessibility, environmental suitability, and strategic alignment with the AIH PMP’s objectives to minimize pest risks, enhance IPM adoption, and ensure compliance with AfDB and Nigerian regulatory frameworks.

3 INSTITUTIONAL ARRANGEMENTS AND RESPONSIBILITIES

Effective pest management within the AIH project requires a multi-tiered, inter-agency institutional structure to ensure streamlined operations, compliance with national and international standards, and successful stakeholder engagement. This chapter defines the roles and responsibilities of key institutions, the coordination architecture, and capacity-building strategies necessary for sustainable Integrated Pest Management (IPM) delivery in the region.

3.1 Institutional and Policy Framework

The PMP aligns with international standards (AfDB's OS 1, OS 2, OS 3, OS 4, OS 6, OS 8, & OS 10) and relevant Nigerian legislation, namely: (i) Nigerian Agricultural Policy (1988) provides general guidance on agricultural practices including pest management; (ii) National Environmental Policy (1989) sets broad environmental standards relevant to pest control activities; (iii) Federal Ministry of Environment (FMEnv) governs the regulation of pesticides, including their disposal and distribution; (iv) National Agency for Food and Drug Administration and Control (NAFDAC) Act F32 LFN 2004 regulates the registration, distribution, and control of pesticide products in industrial settings; (v) National Biosecurity Policy and Action Plan (2022-2026) includes frameworks for integrated pest management systems; (vi) Pest Control of Produce (Special Powers) Act (1968) provides for inspection and control of pests in produce before export and (vii) Factories Act F1 LFN 2004 regulates occupational safety including pesticide handling in industrial settings (e.g., pesticide regulation, pest quarantine, Stockholm Convention) Key institutions include:

- Cross River State Ministry of Agriculture – technical leadership and extension;
- Ministry of Environment – environmental oversight and regulatory enforcement;
- Cross River State ADP – farmer training and capacity-building and Coordination structures shall align with both national policy and IPM governance models.

Policy and Institutional Alignment

Brief mention that the PMP aligns with Nigeria's national agricultural policy, Cross River State agricultural development priorities, and international obligations (e.g., FAO Code of Conduct on Pesticide Management).

3.2 Institutional Roles

The successful implementation of this PMP is contingent upon the defined operational synergy of the following actors:

Cross River State Ministry of Agriculture

Core Function: Lead implementing agency for IPM initiatives.

Responsibilities: Design and disseminate IPM strategies adapted to local agronomic conditions; Supervise field-level surveillance activities; Support seed multiplication of pest-resistant crop varieties; Collaborate with agro-dealers to ensure supply of NAFDAC-approved pesticides.

Justification: As the principal agricultural authority, the Ministry is best placed to translate policy into grassroots implementation via its extension networks.

Cross River State Ministry of Environment

Core Function: Environmental compliance and regulation enforcement.

Responsibilities: Conduct Environmental Impact Assessments (EIA) for pest control operations; Monitor pesticide residues in soil and water bodies; Establish and maintain buffer zones near ecologically sensitive areas; Enforce the ban on Persistent Organic Pollutants (POPs) per the Stockholm Convention.

Justification: The ministry ensures that pest control practices do not compromise environmental integrity.

Cross River State Agricultural Development Programme (ADP)

Core Function: Farmer outreach and technical training.

Responsibilities: Organise Farmer Field Schools (FFS) and participatory learning platforms; Develop simplified IPM modules in local languages for adoption; Act as field-level surveillance agents and data collectors.

Justification: The ADP has established rapport and trust with smallholder farmers, making it an ideal vehicle for dissemination and adoption.

SAPZ Steering Committee

Core Function: Inter-institutional and multi-stakeholder coordination.

Composition: Representatives from Ministries of Agriculture and Environment

CRUTECH (UNICROSS) researchers and entomologists; Agro-processing firms, farmer cooperatives, and local government officials

Responsibilities: Organize quarterly technical review meetings; Ensure the plan's consistency with industrial processing needs; Mobilize technical support from development partners.

Justification: A coordinated body ensures that pest management strategies align with SAPZ processing timelines and standards.

3.3 Coordination Mechanism

An effective PMP hinges on seamless data flow, timely decision-making, and resource optimization across agencies. The proposed coordination framework includes:

Monthly and Quarterly Coordination Meetings: Regular (quarterly/monthly) meetings, a central PMP dashboard for monitoring, and a shared digital system for reporting pest data and intervention measures.

Centralized PMP Dashboard: A digital platform to track pest incidence, pesticide usage, intervention coverage, and yield trends.

Digital Reporting Tools: Mobile apps and SMS platforms for real-time pest reporting by farmers and extension agents; GIS-powered mapping tools to visualize pest hotspots and support timely intervention. This aligns with World Bank and FAO recommendations for digitized and decentralized pest monitoring systems in Sub-Saharan Africa.

To strengthen pest surveillance and ensure seamless communication, the PMP establishes a digital reporting framework that links farmers, extension agents, agro-dealers, and regulatory authorities under the AIH system. The flowchart (Farmers/IPM Scouts → Extension Officers → PMP Dashboard → Ministries (MoA, MoEnv, MoH) → SAPZ Steering Committee → AfDB/Donors) outlines reporting lines, joint meetings, and information-sharing channels:

1. Farmers and IPM Scouts

- Record pest incidence, crop conditions, and pesticide use through mobile apps, SMS short codes, and WhatsApp groups.
- Share data with Ward Extension Officers in real time.

2. Ward/Block Extension Officers (ADP)

- Verify reports, consolidate farmer data, and upload to the PMP Monitoring Dashboard.
- Convene monthly ward-level meetings with farmer groups, women/youth associations, and local leaders for feedback.

3. Local Agro-Dealers and Input Suppliers

- Provide pesticide sales/use data and feed into extension reports.
- Participate in quarterly joint review meetings with ADP and MoA.

4. State Ministries (MoA, MoEnv, MoH)

- Receive validated data through the dashboard.
- MoA: Oversees pest trends and IPM adoption.
- MoEnv: Monitors environmental residues and safeguards.
- MoH: Tracks pesticide-related health incidents.
- Hold quarterly inter-ministerial meetings for coordination.

5. SAPZ Steering Committee (Cross River State)

- Consolidates ministry-level reports, reviews implementation progress, and ensures AfDB safeguard compliance.
- Provides feedback to ministries, ADP, and local farmer groups.

6. AfDB/Donor Partners

- Receive semi-annual reports from the Steering Committee, aligned with ISS/ESS requirements.
- Participate in annual review meetings with government and stakeholders.

3.4 Capacity Building and Need Assessment

A preliminary **needs assessment** has been conducted to identify existing knowledge and capacity gaps among key stakeholders, including ADP staff, farmers, and cooperatives. The findings highlight the following:

- **ADP Staff:** While extension officers possess general agronomic knowledge, most lack specific skills in pest scouting, economic threshold calculations, use of digital reporting tools, and integrated pest management (IPM) decision-making.
- **Farmers:** Many farmers are familiar with traditional pest control practices but show limited awareness of safe pesticide handling, personal protective equipment (PPE), and the risks of Highly Hazardous Pesticides (HHPs). Knowledge gaps also exist in post-harvest pest management and storage pest prevention.
- **Cooperatives and Farmer Groups:** Though organized for collective marketing, cooperatives often lack technical capacity in pesticide inventory management, proper disposal of containers, and coordinated pest surveillance.

Tailored Training Content

To address these gaps, the PMP integrates differentiated training modules for stakeholders:

1. **For ADP Staff:** Digital pest reporting tools, calibration techniques, IPM decision-support, and AfDB/NAFDAC compliance protocols.
2. **For Farmers:** Pest identification, IPM practices (resistant varieties, crop rotation, cultural and biological controls), safe pesticide handling, PPE use, and post-harvest pest management.
3. **For Cooperatives:** Collective pest surveillance, pesticide stock and inventory management, safe storage and disposal of containers, and coordination of community-based IPM.

Workshops and field demonstrations

Workshops and field demonstrations on IPM and SOPs, use of PPE, safe chemical handling, and mobile-based surveillance tools. Building local capacity is a central tenet of IPM sustainability. The details of the strategies toward capacity building for IPM is presented in Table 8.

Table 8: Capacity Building for IPM

Beneficiary Group	Capacity-Building / Training Activity	Project Phase	Estimated Cost (₦)	USD Equivalent (@₦1555/\$)
Smallholder Farmers (men & women across 10 wards)	Farmer Field Schools (FFS) on IPM, safe pesticide use, hermetic storage, biological control	Pre-construction & Operation	2,500,000	\$1,609
ADP Extension Agents (30 agents)	Training-of-Trainers (ToT) on pest surveillance, reporting, and emergency response	Pre-construction	1,800,000	\$1,158
Youth IPM Scouts (20 trained)	Pest scouting, digital reporting, PPE use	Construction & Operation	1,200,000	\$772
Warehouse Managers (AIH storage facilities)	Post-harvest pest management, fumigation protocols, record-keeping	Operation	1,000,000	\$643
Licensed Fumigators	Safe phosphine fumigation, emergency response, exposure monitoring	Operation	1,500,000	\$965
Community Focal Persons / GRM Desk	Gender & youth inclusion in pest management, grievance redress training	All Phases	900,000	\$579
Women and Youth Associations	IPM entrepreneurship, biological-control agent rearing	Operation	1,300,000	\$836
SAPZ Steering Committee & Local Government Officials	Oversight on IPM compliance and data dashboard use	Pre-construction & Construction	800,000	\$515
TOTAL			11,000,000	\$7,074

4 PEST ASSESSMENT AND SURVEILLANCE

Effective pest management begins with timely, reliable, and scientifically grounded assessment and surveillance. This chapter outlines crop-specific pest threats, data-driven surveillance techniques, and spatial risk analysis designed to inform evidence-based interventions in the AIH, Adiabo project area. The methodology adheres to international pest risk assessment and monitoring standards as outlined by the FAO, IPPC, and World Bank environmental guidelines.

4.1 Crop-Specific Pest Profiles A summary of primary threats

Each crop within the AIH project has distinct vulnerabilities to both field and storage pests. The following are key pests that warrant monitoring and targeted control while Table 9 provides the summarized details of the crop-specific pest.

4.1.1 Cocoa (*Theobroma Cacao*)

The primary pests threatening cocoa include:

- Cocoa Mirids (capsids): These are the most serious pests causing damage to cocoa pods and leaves. Monitoring and targeted control measures such as farmer field school trainings on pest management have been conducted to improve knowledge and control techniques.
- Cocoa Swollen Shoot Virus transmitted by mealybugs: This affects the health of cocoa trees and yields.
- Other pests include whiteflies and beetles that warrant monitoring as part of integrated pest management (IPM).

4.1.2 Rice (*Oryza sativa*)

Key pests in rice cultivation include:

- Stem Borers and Leaf Folders: These insects bore into rice stems and fold leaves causing significant damage. Biological control agents such as *Trichogramma spp.* Are released for control.
- Rice Caseworm, Cutworm, and Swarming Caterpillar: Mechanical practices like clipping seedling tips and field sanitation are used to minimize carryover.
- Birds (like quelea quelea): Cause damage primarily to rice grains and require bird scaring methods as it is a common in the area.
- Rodents: Managed through traps and baiting.

4.1.3 Cassava (*Manihot esculenta*)

- Cassava Green Mite (*Mononychellus tanajoa*): Causes chlorosis, reduced photosynthetic capacity, and poor tuber formation.
- Cassava Mealybug (*Phenacoccus manihoti*): Stunts plant growth and causes leaf deformation.

4.1.4 Yam (*Dioscorea* spp.)

- Yam Beetles (*Heteroligus* spp.): Bore into tubers in the field.
- Nematodes (*Scutellonema bradys*): Attack tubers during storage, reducing market value.

4.1.5 Maize (*Zea mays*)

- Stem Borers (*Busseola fusca*, *Sesamia calamistis*): Feed on maize stems, impeding nutrient flow.
- Maize Weevils (*Sitophilus zeamais*): Damage grains during storage, leading to up to 40% losses in poorly ventilated stores.

4.1.6 Legumes (Cowpea, Bambara Nut, Sesame)

- Pod Bugs (*Clavigralla* spp.): Suck sap from pods, causing premature drying.
- Bruchids (*Callosobruchus maculatus*): Infest seeds during storage, reducing viability.

Table 9: Specific-Crop Pest of AIH

Crop	Major Field Pests AIH	Major Storage Pests
Cocoa (Theobroma cacao)	Cocoa mirids (<i>Sahlbergella</i> spp. & <i>Distantiella</i> spp.), whiteflies, mealybugs transmitting Swollen Shoot Virus	<i>Ephestia cautella</i> , <i>Tribolium castaneum</i> in beans
Rice (Oryza sativa)	Stem borers (<i>Busseola fusca</i> , <i>Sesamia</i> spp.), leaf folders, rice caseworm, cutworm, swarming caterpillar, quelea birds, rodents	<i>Sitophilus oryzae</i> , <i>Rhyzopertha dominica</i>
Cassava (Manihot esculenta)	Cassava green mite (<i>Mononychellus tanajoa</i>), cassava mealybug (<i>Phenacoccus manihoti</i>)	<i>Prostephanus truncatus</i> , <i>Dinoderus</i> spp. in dried chips
Yam (Dioscorea spp.)	Yam beetle (<i>Heteroligus</i> spp.), nematodes (<i>Scutellonema bradys</i>)	<i>Dinoderus porcellus</i> in yam chips
Maize (Zea mays)	Stem borers (<i>Busseola fusca</i> , <i>Sesamia calamistis</i>), fall armyworm (<i>Spodoptera frugiperda</i>)	Maize weevils (<i>Sitophilus zeamais</i>), larger grain borer (<i>Prostephanus truncatus</i>)
Legumes (cowpea, bambara nut, sesame)	Pod bugs (<i>Clavigralla</i> spp.), aphids, mites	Bruchids (<i>Callosobruchus</i> spp.), <i>Tribolium</i> spp. in sesame

4.2 Surveillance Strategy

Effective surveillance is the foundation of pest management at the AIH Adiabo. This strategy sets out how pest populations will be monitored, who will be responsible at each level, and when surveillance activities will take place throughout the crop and project cycle.

Objectives of the Surveillance Strategy

The objectives of surveillance are to:

- Detect early pest infestations and disease outbreaks on target crops;
- Determine the abundance and distribution of pests and natural enemies to inform decision-making on control measures;
- Provide data for evaluating the effectiveness of integrated pest management (IPM) interventions and regulatory compliance.

Surveillance Methods (How It Will Be Done)

- i Field Scouting and Sampling: Trained youth IPM scouts and extension agents will conduct regular field scouting using standard sampling protocols for each crop. This includes transect walks, quadrant counts, sweep-net sampling, and visual inspection of leaves, stems, pods and storage facilities. GPS-enabled tablets will be used to geo-reference observations.
- ii Traps and Monitoring Devices: Light traps, pheromone traps (for stem borers, armyworms) and sticky cards (for whiteflies, mealybugs) will be deployed in representative fields. Trap counts will be recorded weekly to monitor pest flight activity.
- iii Damage Assessments and Thresholds: Economic Threshold Levels (ETL) specific to each crop will be applied to decide when to trigger interventions. For example, mirid counts on cocoa pods, percent leaf infestation for stem borers, or bruchid emergence rates in stored legumes.
- iv Community-Based Reporting: Farmers will be trained to observe and promptly report unusual pest activity through a simple SMS/WhatsApp platform coordinated by the AIH EHS Officer. This participatory approach increases coverage beyond official scouting routes.

Roles and Responsibilities (Who Will Do It)

- i Cross River ADP Plant Protection Unit: Technical leadership, design of sampling protocols, quality control of data, and liaison with NAFDAC for regulated pests.
- ii AIH Environmental, Health and Safety (EHS) Officer: Site-level coordination, deployment of traps, data collation and transmission to the PMP dashboard.

- iii Extension Agents: Routine field scouting, farmer mobilisation, on-the-spot advisories and data entry.
- iv Youth IPM Scouts: Day-to-day pest scouting in fields and storage facilities, trap maintenance, and first-line reporting.
- v Farmer Groups / Community Focal Persons: Provide local intelligence on outbreaks, assist in sample collection and validation.
- vi National Quarantine Service (when relevant): Verification of new or invasive pest detections.

Timing and Frequency (When It Will Be Done)

- i Pre-construction Phase: Training of trainers (extension agents, youth scouts) on surveillance protocols; procurement and installation of traps; baseline pest survey of all AIH-linked farms.
- ii Construction Phase: Continued surveillance on demonstration plots and surrounding farms to track pest dynamics during land clearing and establishment activities.
- iii Operation Phase: Full-scale routine surveillance covering all AIH-linked farms and storage facilities:
 - a. Field scouting: Weekly for high-risk crops (rice, maize, legumes); bi-weekly for cassava and cocoa.
 - b. Trap monitoring: Weekly counts and maintenance.
 - c. Storage inspections: Monthly checks of warehouses for post-harvest pests.
 - d. Annual review: End-of-season data analysis and adjustment of thresholds.

Data Management and Reporting

All surveillance data will be geo-referenced and uploaded monthly to the PMP dashboard managed by the AIH EHS Officer. The dashboard will generate maps of pest hotspots and trend graphs to support timely decision-making. Summaries will be submitted to the Project Steering Committee and AfDB as part of quarterly reports.

Linkage to Decision-Making and IPM

Surveillance results will directly inform the deployment of biological, cultural or chemical controls. When ETLs are reached, extension agents will advise farmers on appropriate measures from the approved IPM menu. This ensures interventions are evidence-based and cost-effective.

4.2.2 Digital Reporting Tools

Digital reporting of pest incidence and control actions is already in use in several Nigerian states and will be adapted for the AIH project to strengthen surveillance and decision-making. Since 2022, the Federal Ministry of Agriculture and Rural Development has rolled out the FMARDPACE e-Extension system and NAERLS' "Pest Tracker" app across selected ADPs. Cross River ADP has participated in pilot schemes where extension agents use smartphones and WhatsApp groups to report outbreaks of fall armyworm, mirids and stem borers in near real-time. Similarly, FAO's eLocust3m platform has been used successfully for locust and grasshopper monitoring in northern Nigeria. These examples demonstrate that digital pest reporting is not theoretical but an ongoing practice within Nigeria's extension system.

4.2.3 Application at the AIH

Building on these experiences, the AIH PMP will adopt a two-tiered system:

- i Smartphone App Reporting: Trained youth IPM scouts and AIH EHS staff will use the NAERLS "Pest Tracker" or a customised open-source app to geo-reference pest observations, upload photos, and record control actions.
- ii SMS/WhatsApp Alerts: For farmers without smartphones, simple text or WhatsApp messages will be used to report unusual pest activity or to receive advisories from extension agents.

4.2.4 Implementation Responsibilities

- i Cross River ADP Plant Protection Unit will provide technical leadership, configure the reporting templates, and train extension agents.
- ii AIH Environmental, Health and Safety (EHS) Officer will coordinate field data collection and transmission to the PMP dashboard.
- iii Youth IPM Scouts and Community Focal Persons will be the first-line reporters from farms and storage facilities.

4.2.5 Timing

- i Pre-construction Phase: Training of trainers, configuration of the digital platform, procurement of smartphones/data packages.
- ii Operation Phase: Full deployment during the first planting season, with continuous reporting thereafter.
- iii Quarterly Reviews: Evaluate data quality, coverage and response times; adjust training and tools as needed.

4.2.6 Linkage to Decision-Making

All reports will feed into the PMP dashboard managed by the AIH EHS Officer. Maps of pest hotspots and trend graphs will support timely advisories, trigger IPM measures at or before Economic Threshold Levels, and feed back into quarterly AfDB reporting

4.3 Risk Mapping

Pest prevalence is not uniform across the CR-SAPZ’s AIH project area. Hence, Geographic Information System (GIS)-based risk mapping is crucial.

4.3.1 Hotspot Identification

Integration of historical outbreak records, climatic variables, and crop calendar data to map high-risk zones.

Use of satellite imagery and remote sensing tools to track vegetative stress indicative of pest presence.

4.3.2 Prioritization Matrix

A matrix scoring system which classifies zones into high, medium, or low-risk categories to optimize resource allocation is presented in Table 6.

Table 6: A matrix scoring system

Zone	Crop	Pest Pressure Index	Action Priority
Odukpani Central	Cassava	High	Immediate
Odukpani South	Yam	Medium	Routine Monitoring
Akamkpa	Maize	Low	Trapping Only
Biase	Cocoa	High	Immediate
Adiabo	Rice	Moderate to High	Regulate surveillance

4.3.3 Integration with SAPZ Processing Schedules

Pest maps will guide harvesting, post-harvest storage, and agro-processing timelines to avoid contamination and storage loss. This spatial intelligence will enhance pre-emptive response and rationalize pest management logistic.

4.4 Pest Detection Analysis Using GIS And Remote Sensing

The AIH will deploy a practical, low-cost pest detection system through Geographic Information Systems (GIS) and Remote Sensing (RS) combined with on-the-ground scouting/truthing. The use of GIS and RS at AIH will help to detect and monitor pest dynamics. The approach provides an early-warning system for pest outbreaks on target crops (cocoa, rice, cassava, yam, maize, legumes), map crop areas, pest habitats and hot-spots to prioritise IPM interventions and integrate field observations from scouts with free satellite imagery to improve accuracy and cost-effectiveness.

4.5 Data Sources and Tools

- i Satellite Imagery: Free Sentinel-2 (10 m) and Landsat-8/9 (30 m) data for NDVI and vegetation condition index (VCI) mapping.
- ii GIS Software: ArcGIS and Google Earth Engine for simple processing.
- iii Mobile Data Collection: GPS-enabled smartphones or tablets with apps such as KoboCollect or ODK to geo-tag pest observations from youth scouts and extension agents.
- iv Integration Platform: All data uploaded to the AIH PMP dashboard to generate live maps.

These are the same tools used by NAERLS and FMARD for fall armyworm and locust monitoring in Nigeria, proving their practicality.

4.4.1 Methodology Flow

The pest detection system will follow a simple, repeatable workflow:

- i Field Scouting: Youth IPM scouts and extension agents collect geo-tagged pest observations weekly during field visits to cocoa, rice, cassava, yam and maize plots.
- ii Data Upload: Observations are uploaded the same day to the AIH PMP dashboard using smartphones and Kobo/ODK forms.
- iii Satellite Imagery: The AIH EHS Officer downloads free Sentinel-2 and Landsat imagery every two weeks from USGS/Google Earth Engine.
- iv Overlay and Analysis: Pest points are overlaid on Normalized Difference Vegetation Index (NDVI), vegetation condition index (VCI), chlorophyll fluorescence maps in ArcGIS to detect vegetation stress and hotspots (detailed procedure provided in Annex A).
- v Action Alerts: When anomalies match pest thresholds, the EHS Officer issues alerts to extension agents and farmer groups for immediate intervention.
- vi Feedback Loop: Outcomes of interventions are fed back into the system to refine thresholds.

4.4.2 Techniques for Detecting Pest-Induced Plant

The techniques for detecting pest-induced plants are based on vegetative stress signature and decrease in NDVI which could lead to reduced or loss of chlorophyll, vigour, disrupted canopy structure, and altered water balance. For the AIH, the field signatures relevant to local crops includes:

- i **Cocoa:** Mirid feeding and swollen shoot cause canopy thinning and yellow patches detectable as low NDVI.
- ii **Rice:** Stem borer or caseworm infestations lead to “dead heart” symptoms visible as NDVI dips at tillering stage.
- iii **Cassava:** Green mite and mealybug attacks cause leaf drop and stunting, lowering NDVI relative to healthy plots.

- iv **Yam:** Beetle and nematode damage reduce vine vigour, also visible as weak NDVI patches.
- v **Maize:** Fall armyworm defoliation produces characteristic canopy loss captured by NDVI anomalies.

AIH scouts will be trained to relate these visual symptoms to mapped anomalies, making the link between satellite signal and real pest damage.

4.4.3 NDVI and VCI Mapping for AIH

The NDVI of the project site (Figure7) indicates that 71.7% of the project area recorded high vegetation index not exceeding 0.198 which is equivalent to 20%, an indication that the healthy vegetation status of the area has dropped significantly and this is not unconnected to continuous cropping in successive years (compare to high index in forested area). This also implies that the susceptibility of the crops to pest attack is very high due to low resistivity ability of the crops which will result in decline productivity. Hence, pest control measures become very necessary. AIH EHS staff will generate NDVI anomaly maps bi-weekly during the growing season to prioritise surveillance visits to cocoa, rice, cassava, yam and maize fields.

For VCI map (Figure 8) for AIH Adiabo indicates, the stress condition of the vegetation is moderate (not extremely stressed) which shows that to a very large extents, it is still exposed to pest attack. Thresholds will be adjusted annually based on local field validation for each crop.

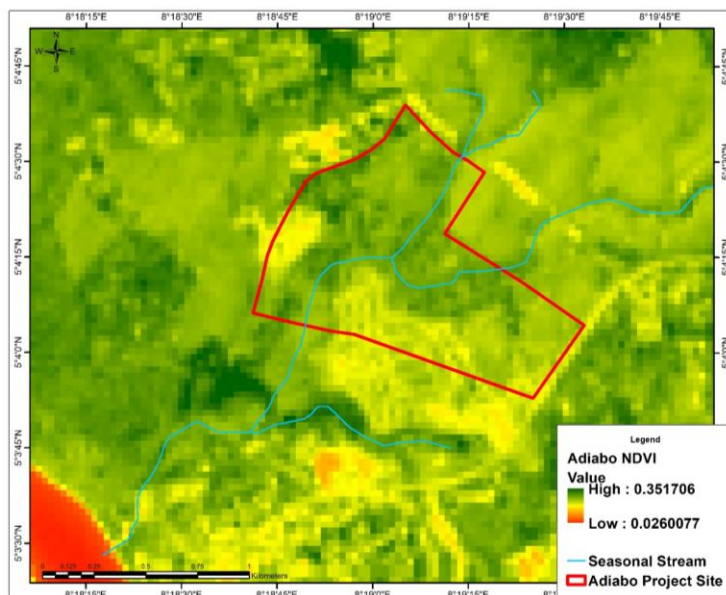


Figure7 : Normalized Difference Vegetation Index (NDVI) of Adiabo Project Site and its Environs

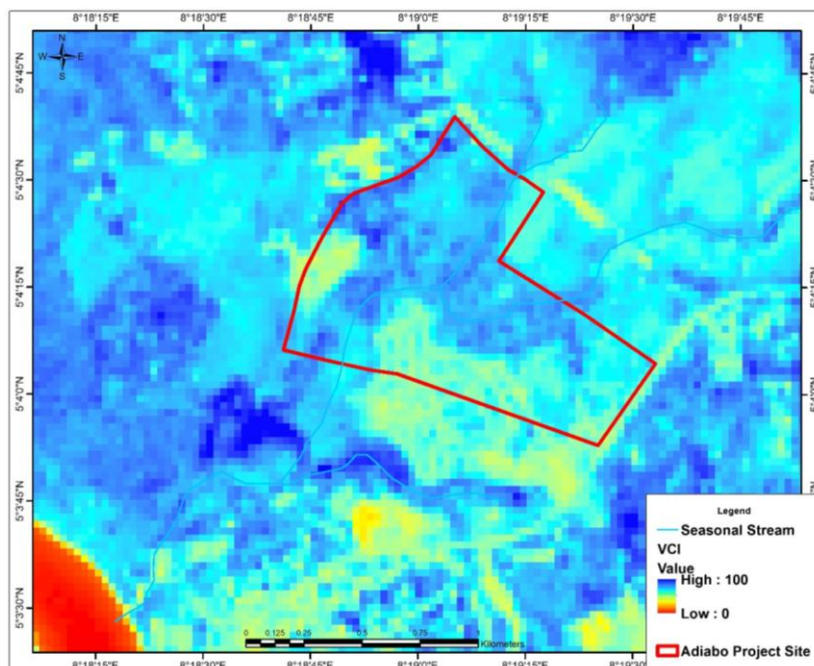


Figure 8: Vegetation Condition Index (VCI) Map

4.4.5 Site Vulnerability to Pest Infestation

The vulnerability of each of the major crops to pest infestation was analysed through integration of RS indices and the outcome was presented in Figure 9 to Figure 13. This makes vulnerability mapping a practical decision-support tool.

- **Inputs:** NDVI/VCI maps, soil moisture, slope and past pest records from ADP.
- **Output:** Quarterly vulnerability maps highlighting specific blocks within the AIH and surrounding out-grower farms for cocoa, rice, cassava, yam and maize.
- **Use:** Directs where traps, biopesticide sprays or biological releases are deployed first, reducing costs and chemical use.

Crop Vulnerability Profiles

The vulnerability analyses have been simplified for farmer and extension use:

Cocoa

Figure 9 shows the vulnerability status of the project site to pest/disease attacks with respect to cocoa plantation. The result indicates that no place in the project site is free from pest attack when cocoa is planted. Thus, 43.3% and 54.9% of the project site is highly and moderately vulnerable to pest infestation respectively while 1.8% is marginally vulnerable. This is an indication that the project site required a very good cocoa pest control measures to protect the crops while optimizing productivity.

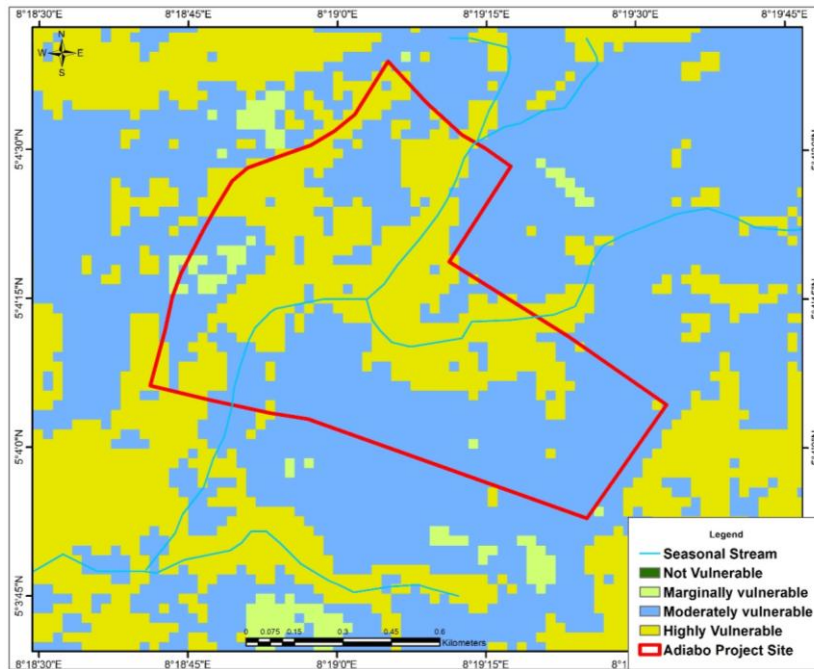


Figure 9 : : Cocoa Vulnerability Map to Pest Infestation

Rice (*Oryza sativa*)

The integration of the parameters with respect to rice requirements shows that 72.17% of the project area is highly vulnerable to pest infestation when rice is cultivated. Similarly, 25.6% of the project sites is moderately vulnerable to pest attack while 2.3% is not vulnerable to rice pest infestation (**Error! Reference source not found.**).

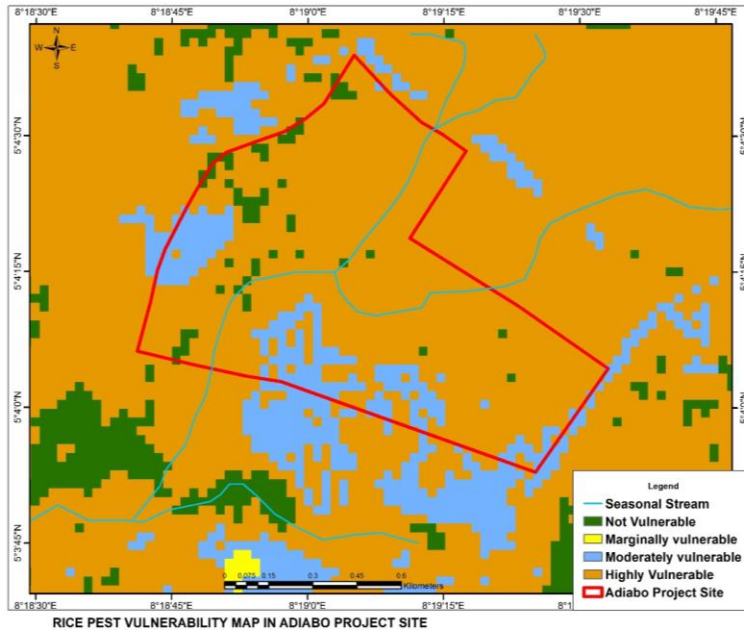


Figure 5: Rice Vulnerability Map to Pest Infestation

Cassava (*Manihot esculenta*)

Figure 6 shows cassava vulnerability map to pest infestation within Adiado project environment, indicating that less than 44.56% of the project area is highly vulnerable to cassava pest infestation, 48.27% is moderately vulnerable while 7.17% is marginally vulnerable.

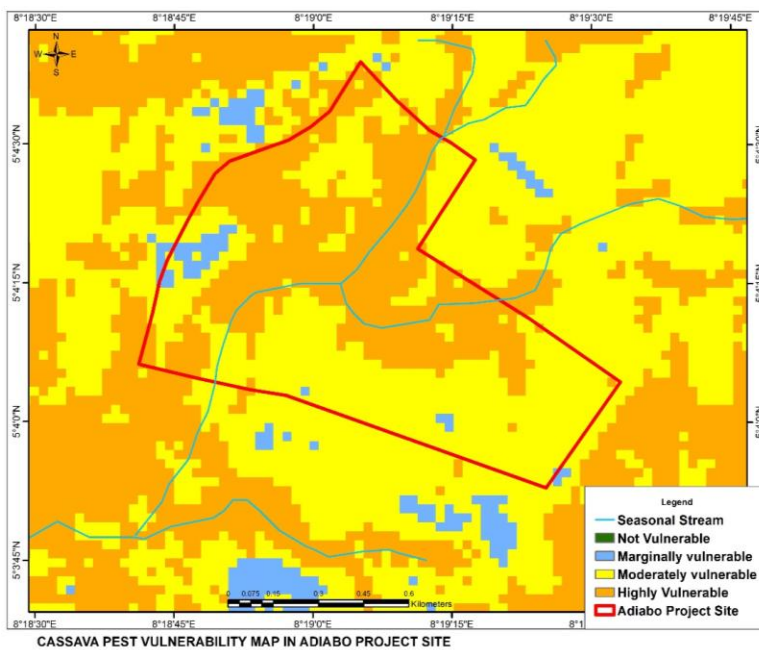


Figure 6: Cassava Vulnerability Map to Pest Infestation

Yam (*Dioscorea spp.*)

Yam vulnerability map shows that 34.2% is highly vulnerable while 18.6% is moderately vulnerable. Similarly, 47.0% of the project site is marginally vulnerable to yam pest attack while less than 1% of the area is not vulnerable at all (Figure).

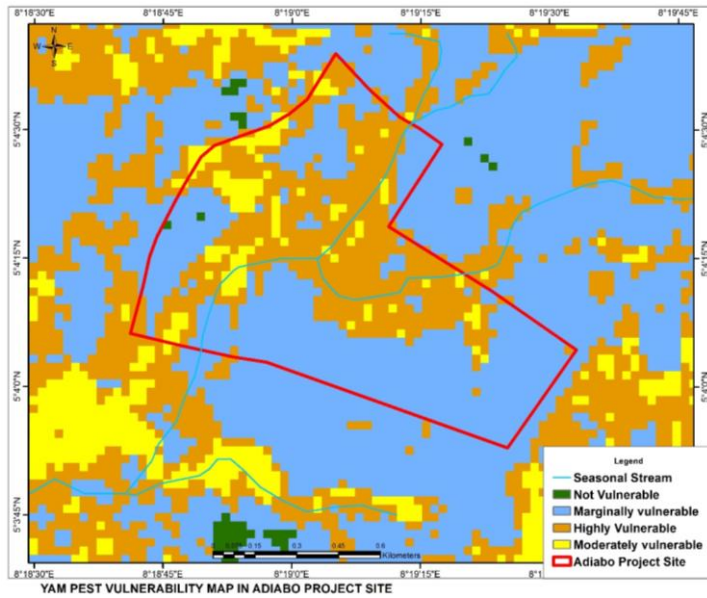


Figure 7: Yam Vulnerability Map to Pest Infestation

Maize (*Zea mays*)

The maize pest vulnerability map shows that about 33.2% of the project site is highly vulnerable to maize pest effect. Similarly, 49.7% and 17.1% are moderately and marginally vulnerable to maize pest attack respectively, implying that none of the project site is totally free from pest if maize is planted (Figure).

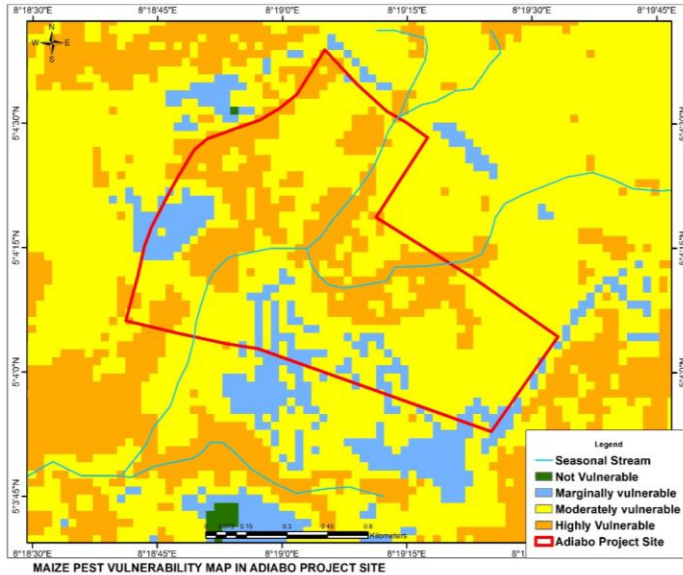


Figure 8: Maize Vulnerability Map to Pest Infestation

Legumes (Cowpea, Bambara Nut, Sesame)

The pest vulnerability map for legumes shows that about 68.2% of the project site is highly vulnerable to legume pest effect. Similarly, 22.4% and 9.4% are moderately and marginally vulnerable to maize pest attack respectively, while no portion of the project site is totally free from pest if legumes are planted (Figure).

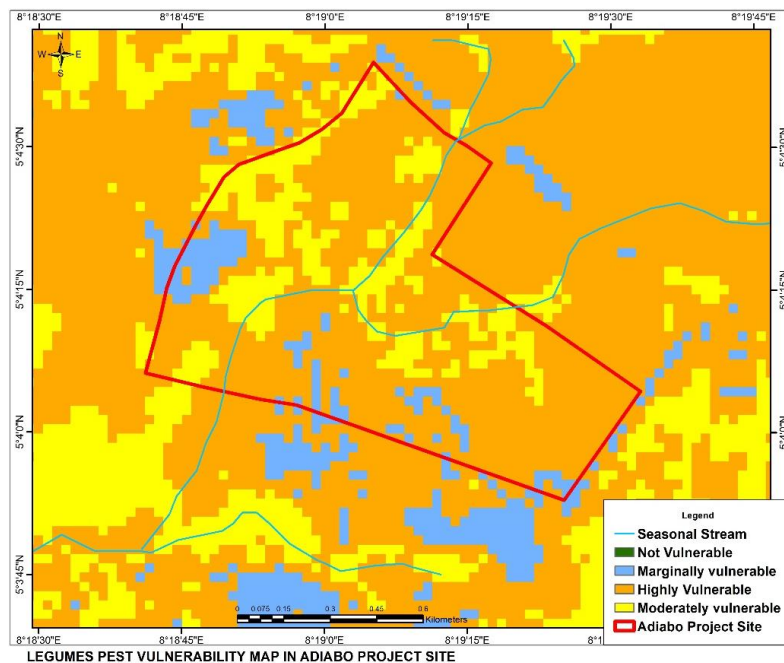


Figure 9: Legumes Vulnerability Map to Pest Infestation

Conclusion

The study employed an integrated AHP and GIS approach to assess crop pest and disease vulnerability in the project area taking into consideration major crops such as cocoa, yam, cassava, maize, among others. The study emphasized areas prone to pests and diseases which required supporting proactive management. This approach facilitated comprehensive risk assessment and decision-making, aiding agricultural resilience. The result shows that all the major crops in the area are at higher risk of pest attack, thereby calling for the need for appropriate control measures. The implications of the vulnerability map underscored the need for tailored management strategies.

5 EXISTING CONTROLS AND NATURE-BASED SOLUTION FOR PEST MANAGEMENT

5.1 Introduction

The sustainability of the AIH supply chains (cocoa, rice, cassava, yam, maize, legumes) depends on pest management approaches that protect yields and quality while minimising harm to people and the environment. The AIH sits within the humid forest–savannah transition zone of Cross River State, where farmers have a long tradition of blending biological controls and cultural practices with selective pesticide use. This provides a strong foundation for a Pest Management Plan built on practices that are already proven in Nigeria and in ecologies similar to Adiabo. By capturing existing biological vector and pest control (BPC) measures and nature-based solutions (NBS) and organising them into a structured programme, the PMP reduces reliance on hazardous pesticides, safeguards worker and community health, and stabilises the supply of cocoa, rice, cassava, yam, maize and legumes into the AIH processing chain.

5.2 Current Practices in Cross River and Comparable Ecologies

Farmers around the AIH practices a range of low-cost, locally adapted measures. In cocoa-growing areas of Boki and Ikom, canopy management, pruning and retention of beneficial shade trees provide habitat for natural predators of mirids and mealybugs. Along the Cross-River rice valleys, smallholders synchronise planting, drain canals at key stages, and maintain field sanitation to suppress stem borers and rodents. Cassava farmers throughout southern Nigeria benefit from established biological control of cassava mealybug (*Apoanagyrus lopezi*) and routinely intercrop with legumes to conserve soil and predator populations. Yam farmers employ rotation and timely staking to reduce nematodes and beetle damage, while maize and cowpea growers in the Middle Belt increasingly use pheromone traps, neem-based sprays and hermetic storage bags to manage field and storage pests.

These examples demonstrate that the methods proposed in the PMP are not hypothetical. They are already in use in Nigeria, under conditions comparable to those at Adiabo, and can be scaled with training, coordination and modest investment.

5.3 Biological Vector and Pest Control (BPC) for AIH Crops

Cocoa: Existing BPC/NBS measures include canopy thinning, removal of infected pods, and conservation of shade trees, which encourage natural enemies of mirids and mealybugs. Farmers in nearby Etung LGA use neem extracts as a low-toxicity repellent. The PMP consolidates these practices by scheduling regular pruning and training field scouts to identify early mirid damage.

Rice (*Oryza sativa*): Predatory insects in lowland paddies suppress stem borers and caseworms when pesticide use is restrained. Integrated field sanitation—synchronised planting, residue removal, and managed irrigation—limits pest build-up. *Trichogramma* parasitoid releases, successfully piloted in Benue and Niger States, are planned for Adiabo’s out-grower paddies with technical support from NAERLS.

Cassava (*Manihot esculenta*): Classical biological control of cassava mealybug remains effective in Cross River. The PMP strengthens this by promoting resistant cassava varieties, intercropping, and maintaining hedgerows and native shrubs to house predators.

Yam (*Dioscorea spp.*): Cultural sanitation, crop rotation, and the use of healthy seed yams reduce nematodes and beetle infestations. Organic soil amendments demonstrated in southeastern Nigeria improve soil health and suppress pests naturally.

Maize (*Zea mays*) and Legumes: Farmers are beginning to adopt pheromone traps, Bt biopesticides and push–pull intercropping to manage fall armyworm and pod borers. The PMP will pilot adapted push–pull species on demonstration plots at Adiabo and distribute hermetic storage bags (PICS) to reduce post-harvest losses and mycotoxin contamination.

5.4 Nature-Based Solutions in the Landscape

Nature-based solutions at AIH extend beyond individual fields. Establishing flowering hedgerows and vegetated buffer strips around production zones preserves pollinators and parasitoids, stabilises soils and reduces pesticide drift into streams and wetlands used by local communities. These features already exist in parts of Cross River’s cocoa belt; under the PMP they will be deliberately designed into the AIH land-use plan. Simple water-management practices—such as alternating wetting and drying in rice paddies—suppress mosquito vectors and reduce public-health risks without extra chemicals.

5.5 Integration into the PMP Operational Framework

Within the PMP, these BPC and NBS practices are integrated into a surveillance–threshold–intervention framework:

- **Surveillance:** Youth IPM scouts and extension agents trained under the PMP will carry out routine field inspections and trap monitoring.
- **Threshold-based Action:** Biological and cultural controls will be triggered only when pest densities exceed established economic thresholds, preventing unnecessary interventions.
- **Demonstration and Scale-up:** New practices such as push–pull will be trialled on demonstration plots at Adiabo before wider adoption.

- **Supportive Infrastructure:** The AIH will provide approved biopesticides, pheromone traps, hermetic storage bags and training materials, ensuring farmers have the tools to implement the practices.

5.6 Benefits and Practicability

All recommended measures are grounded in Nigerian experience and require no high technology or imported inputs. They can be implemented with local labour and materials, coordinated through the AIH's extension service. By embedding these controls into everyday farm management and post-harvest handling, the PMP achieves multiple benefits: reduced pesticide residues, improved worker safety, enhanced biodiversity, lower production costs, and stable supply volumes and quality for the AIH's processing operations.

The AIH Pest Management Plan does not invent new methods. It organises a suite of existing biological and nature-based solutions—already proven in Nigeria's humid tropics—into a structured, funded and monitored programme. This approach balances pest suppression with environmental and social safeguards, aligns with AfDB standards and Nigeria's own sustainability goals, and ensures that pest management at the AIH is practical, cost-effective and locally appropriate.

6 PHYTOPHARMACEUTICAL AND AGRICULTURAL EXTENSION SERVICES CAPACITY

The AIH in Adiabo, Odukpani LGA, Cross River State, will aggregate and process cocoa, rice, cassava, yam, maize and legumes from hundreds of smallholder suppliers. While the PMP emphasises Biological Control Practices (BPC) and Nature-Based Solutions (NBS), proportionate chemical inputs will still be required to manage certain pests effectively. This chapter provides a thorough assessment of Nigeria's phytopharmaceutical regulation and agricultural extension services, focusing on their capacity to ensure safe, effective and sustainable chemical use alongside BPC/NBS at the AIH. It examines registration and regulation, extension services, supply chains, monitoring/enforcement/feedback systems, and capacity gaps and constraints. Each subsection begins with an introductory paragraph to set context for the reader.

6.1 Registration and Regulation of Phytopharmaceuticals

Sound pest-management begins with control at the point of entry: what products are allowed into the market. The Nigeria registers and regulates phytopharmaceuticals and how these mechanisms can support or hinder the AIH's PMP was examine.

Current System and Institutions

- i NAFDAC is Nigeria's primary agency for pesticide registration and post-market surveillance. It evaluates dossiers, classifies hazards, issues product certificates and periodically re-registers active ingredients.
- ii Federal Ministry of Agriculture and Food Security (FMAFS) and Federal Ministry of Environment (FMEnv) set complementary policies on safe use, residue limits and disposal.
- iii NESREA enforces hazardous-waste regulations.
- iv Research institutes and labs (e.g. NAERLS, NCRI, Cocoa Research Institute) generate efficacy and residue data used in approvals.

Relevance to AIH

- i A legal framework exists to ensure only approved, low-toxicity products enter the AIH supply chain.
- ii AIH can maintain an Approved Input List based on NAFDAC registration and updated quarterly.

- iii The framework can be leveraged to reject Highly Hazardous Pesticides (HHPs) from outgrower supply.

Gaps and Risks

- Slow re-registration and weak border enforcement allow counterfeit and obsolete products into local markets.
- Limited laboratory capacity delays residue testing and investigative confirmation.
- Smallholders often buy from informal channels with no label comprehension.

AIH-Focused Recommendations

- Create an AIH–NAFDAC liaison for rapid verification of suppliers and products.
- Allocate budget for baseline and periodic residue testing of AIH commodities.
- Use the AIH’s procurement power to push only approved, low-toxicity inputs into the local retail ecosystem.

6.2 Agricultural Extension Services

Even the best regulations fail without effective field delivery. Therefore, considering the Nigeria’s agricultural extension system, with emphasis on Cross River ADP and its ability to support safe pest management at AIH Adiabo.

Current Structure

- i ADPs deliver extension through zonal and block offices.
- ii Cross River ADP maintains a presence in Odukpani LGA but staff–farmer ratios are high (often 1:1,500).
- iii NGOs and private agribusiness provide supplementary advisory services, especially on cocoa.

Strengths for AIH

- i Established extension infrastructure and local knowledge of pest dynamics.
- ii Proven track record running Farmer Field Schools (FFS) and synchronised planting campaigns.
- iii Capacity to mobilise women and youth groups for training.

Weaknesses

- i Limited refresher training on pesticide stewardship and PPE.
- ii Digital capacity uneven; many agents lack smartphones or data plans for real-time surveillance.
- iii Low incentives for extension staff to prioritise AIH activities.

AIH-Focused Recommendations

- i Embed youth IPM scouts funded by AIH but supervised by ADP, doubling field coverage.
- ii Roll out cascade ToT on pesticide stewardship, calibration, PPE, and biological control.
- iii Provide digital kits (smartphones, data, simple apps) for scouts and extension staff.
- iv Establish modest performance-based incentives for extension officers working with AIH outgrowers.

6.3 Supply Chain and Market Regulation

Safe pest management at farm level depends on what is available in the local market. This subsection analyses Nigeria's phytopharmaceutical supply chains, focusing on Cross River's input markets that AIH suppliers use.

Market Structure

Inputs are supplied through a mix of formal distributors, agro-dealers, and informal traders. Farmers often buy from roadside sellers who lack training and sell unregistered products.

Key Issues at Adiabo

- Traceability: no guarantee inputs purchased locally match approved labels.
- Counterfeits: widespread, undermining efficacy and safety.
- Retailer knowledge: most agro-dealers have limited training in IPM or safe-use instructions.

AIH-Focused Recommendations

- Implement procurement gating: only reimburse farmers or input suppliers sourcing from approved distributors.
- Launch an agro-dealer certification programme with signage and training.
- Introduce batch traceability (QR codes) for AIH-procured inputs.
- Conduct market sweeps with regulators to spot and report counterfeits.

6.4 Monitoring, Enforcement and Feedback Systems

Monitoring and enforcement transform policies into practice. This subsection assesses how well Nigeria's systems detect violations and feed lessons back to farmers and suppliers.

Existing Mechanisms

- National regulator conducts occasional inspections of warehouses and borders.
- ADP officers sometimes check input shops, but resource constraints limit coverage.
- Residue testing is sporadic and mostly donor-funded.

Weaknesses Affecting AIH

- Insufficient sampling capacity for residue testing.
- Weak feedback loops; farmers rarely see results of inspections.
- Limited public awareness of approved product lists and reporting channels.

AIH-Focused Recommendations

- Establish a joint AIH–ADP monitoring protocol with scheduled inspections and sampling.
- Contract certified labs for periodic residue testing.
- Create a digital feedback loop to send lab and inspection results to farmer groups and log in the PMP dashboard.
- Run community-awareness campaigns on approved products, safe disposal and reporting mechanisms.

6.5 Capacity Gaps and Constraints

This subsection synthesises the gaps identified above and explains how they could affect AIH Adiabo's pest management, while highlighting opportunities to build capacity.

Key Gaps

- i Regulatory enforcement capacity and laboratory throughput insufficient to screen all market products.
- ii Extension coverage and skills gap in pesticide stewardship, PPE, calibration and safe application.
- iii Supply-chain integrity challenges from informal trade and counterfeit products.
- iv Weak data systems for tracking pesticide use, residues and health incidents.

- v Financial barriers for smallholders to adopt safer alternatives (PICS bags, registered biopesticides, PPE).

Operational Implications for AIH

- i Increased risk of residue exceedances and loss of market credibility.
- ii Worker and community safety compromised without strengthened controls.
- iii Potential undermining of biological control effectiveness through indiscriminate chemical use.

Practical Mitigation and Capacity-Building Roadmap

- i Approved Inputs Policy & Procurement Gate: restrict supply to low-toxicity registered products.
- ii Extension Capacity Reinforcement: fund and equip youth IPM scouts; run a 12-month cascade ToT.
- iii Agro-Dealer Partnerships: certification, signage and retailer training to reduce counterfeit flows.
- iv Targeted Monitoring Programme: seasonal residue testing for high-risk crops and random retail purchases.
- v Digital Reporting & Feedback: smartphone reporting, PMP dashboard and public result dissemination.
- vi Finance Instruments for Smallholders: bulk procurement, partial subsidies for safer inputs in first two seasons.
- vii Institutional MOUs: formalise roles with Cross River ADP, regulator and local government for joint inspections.

Indicators for Monitoring

- i % of agro-inputs procured for AIH that are on the approved list.
- ii Number of extension visits per farm per season.
- iii Number of agro-dealers certified by AIH training.
- iv Number of residue tests conducted and % compliance with MRLs.
- v Number of counterfeit product incidents reported and removed.
- vi % of farmers using hermetic storage (PICS) for key commodities.

vii Number of youth IPM scouts trained and operational.

6.6 Institutional Coordination and Sustainability

Coordination ensures that regulation, extension, supply chain control, monitoring work as one system. AIH should convene a Phytopharmaceutical & IPM Steering Group including Cross River ADP, the national regulator, NAERLS or an equivalent research partner, key agro-dealers, AIH management and farmer representatives to oversee implementation, review monitoring results and coordinate enforcement referrals. This platform strengthens local ownership and aligns the PMP with national policy while enabling rapid corrective action.

Nigeria's registration and extension architecture gives the AIH a solid foundation for safe chemical management, but enforcement gaps, informal supply chains and extension constraints pose real risks. The AIH's PMP can mitigate these risks by combining strict procurement controls, extension strengthening, verified supply channels, targeted monitoring and modest financing support to smallholders. Embedding these measures within existing institutions and feedback systems ensures sustainability and full compliance with national and lender standards.

7 INTEGRATED PEST MANAGEMENT (IPM) STRATEGIES

Integrated Pest Management (IPM) represents the foundation of sustainable crop protection under the Adiabo AIH project. This approach combines cultural, mechanical, biological, and chemical control methods to manage pest populations in an economically viable, socially acceptable, and environmentally sound manner. IPM minimizes dependency on hazardous chemicals while enhancing ecosystem services—particularly natural pest regulation. The IPM strategy is designed to:

- Sustain yields and quality;
- Protect worker and community health;
- Minimise environmental impacts; and
- Comply with national and AfDB safeguard standards.

7.1 Pest Identification and Monitoring

Accurate pest identification and continuous monitoring are the backbone of IPM. Without a structured system, interventions risk being late, unnecessary or misdirected. AIH will profile, monitor and respond to pests in its catchment area.

Pest Profiles and Life Cycles

The PMP maintains detailed profiles of key pests by crop, including identification keys, life cycles, peak infestation periods and Economic Threshold Levels (ETLs):

- i Rice (*Oryza sativa*): African rice gall midge, stalk borers, rice blast.
- ii Cassava (*Manihot esculenta*): cassava green mite, mealybug, bacterial blight.
- iii Yam (*Dioscorea spp.*): yam beetle, scale insects, anthracnose.
- iv Maize (*Zea mays*): stem borers, fall armyworm, maize streak virus.
- v Cocoa: mirids, black pod disease, capsids.

Plate 1, *Plate 2*, *Plate 3*, Plate 4, **Error! Reference source not found.** *Plate 5*, and *Plate 6* present the pictures of some of the pests and diseases encountered in the catchment area of Adiabo.



Plate 1: Cocoa black pod disease



Plate 2: Rice stem borers (1st & 2nd left) and blast disease (1st & 2nd right)



Plate 3: Cassava Mealybugs and mosaic virus disease



Plate 4: Yam beetles and *Anthraco*se



Plate 5: Maize Stem borers (left) and fall army (right)



Plate 6: Bruchids (left) and aphids (right) in legumes

Monitoring Methods

- i Scouting and traps: pheromone, sticky and light traps placed at representative farm clusters, checked weekly by youth IPM scouts.
- ii Life-cycle tracking: linking trap data with crop phenology to predict peak infestations.
- iii Surveillance calendar: seasonal plan indicating scouting frequency, intervention thresholds and reporting deadlines for each crop–pest combination.

Digital Integration

Data will be captured on simple mobile apps (Kobo, NAERLS Pest Tracker, FMARDPACE e-Extension) and uploaded to an AIH PMP dashboard, enabling rapid analysis and decision-making.

7.2 Workers' Training

Even the best-designed IPM plan fails without skilled people to implement it. Training ensures that farmers, extension agents and youth IPM scouts can accurately identify pests, decide when interventions are needed and apply inputs safely.

Training Modalities

- i Farmer Field Schools (FFS): season-long learning plots demonstrating IPM in real time.
- ii Training of Trainers (ToT): Cross River ADP agents and AIH supervisors trained first, then cascading knowledge to farmer groups.
- iii Refresher courses: pre-season workshops each year on pest identification, ETLs, calibration, PPE, storage and emergency procedures.

Training Content

- i Pest identification and life cycles;
- ii Decision-making based on ETLs rather than calendar spraying;
- iii Safe handling, mixing and application of biopesticides and chemical pesticides;
- iv PPE selection, use and maintenance;
- v First aid and incident reporting.

7.3 Environmental, Health and Safety (EHS) Measures

The AIH's IPM strategy protects not only crops but also people and ecosystems.

Key Measures

- i Hazard hierarchy: prioritise BPC/NBS, then engineering controls, administrative controls and finally PPE.
- ii Buffer zones: mandatory no-spray strips along water bodies and settlements.
- iii Medical surveillance: periodic health checks for spray operators and scouts.
- iv Secure storage: ventilated, lockable stores with spill kits and fire extinguishers at AIH and farmer-group hubs.
- v Environmentally sound disposal: triple-rinsing, puncturing and returning empty containers to approved recyclers; safe disposal of obsolete stocks.

7.4 Record Keeping and Documentation

Documented evidence of what is done in the field underpins compliance, traceability and continuous improvement.

- i Field logs: for each farm/cluster noting pest counts, interventions, product used, date, operator and PPE.
- ii Training records: attendance lists, topics covered, PPE issued.
- iii Residue test results and incident reports: kept at AIH HQ and digitised for dashboard analysis.
- iv Compliance audits: quarterly review of records by AIH PMP team.

7.5 Evaluation and Feedback Mechanisms

IPM must adapt to changing pest pressures, climate and farmer behaviour. This subsection sets out how AIH will evaluate effectiveness and feed lessons back.

- i Seasonal reviews: analysis of pest incidence, yield losses, control effectiveness and cost.
- ii Compliance scorecards: % of interventions triggered by ETL, % of approved inputs used.
- iii Community feedback: grievance channels and participatory meetings to capture farmer experiences.
- iv Adaptive management: update surveillance calendars, training curricula and approved product lists based on findings.

7.6 Contingency Measures in the Event of an Outbreak

Despite preventive measures, outbreaks may occur. Rapid, structured response protects yields, prevents spread and maintains market credibility.

- i Rapid verification teams: trained scouts and extension agents to confirm and report outbreaks within 24–48 hours.
- ii Pre-approved emergency pesticide list: low-risk options vetted for crisis use.

- iii Communication protocol: immediate notification of AIH management, ADP, local government and affected communities.
- iv Buffer-zone expansion and targeted spraying: to contain outbreaks while limiting non-target impacts.
- v Post-event evaluation: documenting causes, responses and lessons for future seasons.

7.7 Cultural Practices and Integrated Pest Management

The AIH PMP is designed to build on what farmers in Odukpani LGA and neighbouring LGAs already do, rather than imposing entirely new techniques. In Cross River State, smallholders supplying cocoa, rice, cassava, yam, maize and legumes have long relied on cultural practices as their first line of defence against pests. This section presents those current practices, highlights the strongest (good) practices, identifies gaps, and explains how the PMP will combine them into a coherent strategy before moving to recommendations.

7.7.1 Current Cultural Practices in the AIH Catchment

Field surveys and engagement with Cross River ADP show that farmers currently apply a range of pest-reducing cultural measures:

- i Crop rotation and fallowing between cassava, maize and legumes to break pest life cycles.
- ii Intercropping (maize–cowpea, cassava–legume, yam–vegetable) to reduce host density and diversify income.
- iii Synchronous planting of rice in lowland paddies to suppress stem borer and bird pressure.
- iv Field sanitation: removal of infested crop residues and weeds; destruction of alternate host plants.
- v Pruning and canopy management in cocoa to reduce mirid and black-pod incidence.
- vi Use of locally available botanicals (especially neem extracts) as low-toxicity repellents or protectants.
- vii Timely harvest and basic storage hygiene (cleaning stores, raised platforms, simple drying).

These practices are already embedded in farmer routines and are therefore practical and locally appropriate.

7.7.2 Good Practices Identified

Several practices stand out as consistently effective in the AIH context:

- i Synchronous planting and drainage in rice paddies reduces stem borer and rodent damage.
- ii Cocoa canopy management combined with sanitation has kept mirid populations below economic thresholds in many farms.
- iii Intercropping cassava with legumes maintains soil fertility and reduces mealybug resurgence.
- iv Use of resistant varieties (TME 419 cassava, SAMMAZ 45 maize) has lowered pest incidence.

v Timely harvest and improved drying limit storage losses and mycotoxin contamination. These are “good practices” the PMP will preserve and scale up.

7.7.3 Gaps Identified

Despite these strengths, the baseline assessment found important gaps:

- i Scouting and threshold-based action are not systematic; decisions are still reactive.
- ii Push–pull or trap cropping for maize and legumes is rare.
- iii Pheromone/light traps are largely absent, so farmers lack early warning of pest flights.
- iv Storage hygiene is inconsistent and hermetic storage bags are not widely used.
- v Landscape habitat measures (flower strips, buffer zones) are not planned or maintained collectively.

These gaps explain why pest losses remain high despite existing practices.

7.7.4 Combining and Strengthening Practices

Experience from Nigerian and West African IPM programmes shows that combining cultural practices gives much greater pest suppression than isolated actions. For example:

- **Cassava rotation + intercropping + timely planting** reduces nematodes and mealybugs more effectively than rotation alone.
- **Cocoa canopy management + removal of infected pods + shade tree diversification** lowers mirid populations and disease spread.
- **Rice synchronous planting + field sanitation + *Trichogramma* releases** cuts stem borer infestations to minimal levels.
- **Maize pheromone traps + push–pull + Bt biopesticide** significantly reduces fall armyworm damage.

The PMP will therefore integrate existing farmer practices into “packages” for each crop, supported by training, demonstration plots and simple decision aids. Farmers will see the value of combinations through yield and quality improvements rather than one-off interventions. Crop-Pest- Management of the AIH-PIM in presented in Table 7.

Table 7: Pest list and Management methods per Crop

Crop	Key Pests/Diseases	Management Methods
Cocoa	Capsids (<i>mirids</i>), Black pod	Resistant varieties, pruning, farm sanitation, selective fungicide application
Rice	Stem borers, Blast disease	Resistant varieties, crop rotation, water management, biological control (<i>Trichogramma</i>)
Cassava	Mealybugs, Mosaic virus	Resistant cuttings, crop rotation, regular field monitoring, cultural practices
Yam	Yam beetles, Anthracnose	Use of healthy seed yams, soil sanitation, crop rotation, timely staking
Maize	Stem borers, Fall armyworm	Resistant hybrids, natural predators, intercropping, conservation tillage
Legumes	Bruchids, Aphids	Hermetic storage, intercropping, neem extracts, safe pesticide use

7.7.5 PMP Integration

Under the PMP, these cultural practices will be formalised into:

- i Crop-specific IPM packages for cocoa, rice, cassava, yam, maize and legumes that build on what farmers already do.
- ii Surveillance and early warning using scouts and traps so cultural measures are applied at the right time.
- iii Post-harvest hygiene and hermetic storage as a standard part of the pest-management package.
- iv Training modules and farmer field schools to institutionalise combined practices.

This approach ensures the PMP reflects actual practice on the ground, identifies strengths and weaknesses, and organises cultural controls into a structured, cost-effective system before moving on to chemical or higher-risk options.

7.8 Mechanical & Physical Controls

Mechanical strategies are effective in reducing pest populations through direct physical actions.

- **Manual Removal:** Handpicking of pod bugs and visible caterpillars from fields during scouting.
- **Barriers and Screens:** Use of fine-mesh screens over storage bins to deter bruchids and weevils.
- **Light and Sticky Traps:** Deployed at night for adult moths and beetles; highly effective in reducing initial infestations.
- **Storage Hygiene:** Cleaning of storage structures with soap solution and neem oil prior to storing legumes. These practices are low-cost, environmentally benign, and suitable for smallholders with limited capital investment.

8.2 Biological Control

Biological control is a cornerstone of the AIH PMP. Rather than introducing untested organisms, the PMP builds on beneficial insects, microbes and botanicals that are already approved and widely used in Nigeria's humid agro-ecological zones. This makes the approach both effective and low risk.

Effectiveness in the Nigerian Context

Across southern and central Nigeria, classical and augmentative biological controls have been shown to deliver substantial pest reductions:

- The parasitoid *Apoanagyrus lopezi*—introduced in the 1990s for cassava mealybug—remains established and continues to suppress mealybug populations without repeated release or adverse effects.

- *Trichogramma* egg parasitoids are being used in rice and maize IPM pilots in Benue, Niger and Cross River States with measurable reductions in stem borer infestation.
- Registered microbial biopesticides such as *Bacillus thuringiensis* (Bt) for lepidopteran pests, and entomopathogenic fungi (*Beauveria*, *Metarhizium*) for soil and foliar pests, have been validated under Nigerian field conditions.
- Neem-based products, produced locally and registered by NAFDAC, have been used by smallholders in Cross River to manage mirids in cocoa and armyworm in maize.

Field trials and farmer-reported outcomes indicate yield increases of 10–30 percent when these agents are used at recommended timings and combined with cultural practices. By relying on proven agents and application methods, the PMP can scale biological control quickly and cost-effectively within the AIH catchment.

Managing the Risk of Invasive Species

The PMP does **not** propose to import new exotic predators or parasites. All biological control agents mentioned are either:

- Indigenous natural enemies conserved through habitat management, or
- Long-established classical control agents already approved by national authorities, or
- Registered biopesticides (microbial or botanical) under NAFDAC.

Augmentative releases (such as seasonal *Trichogramma* releases in rice paddies) will be sourced from local or national rearing facilities and applied under Cross River ADP and AIH extension supervision. Every release will be logged, and post-release monitoring will confirm establishment and check for non-target effects. Conservation biological control measures—such as hedgerow planting and avoiding broad-spectrum insecticides—simply enhance naturally occurring predators and parasitoids and carry no risk of becoming invasive.

Integration with Other Pest Management Practices

Biological methods at AIH are not used in isolation but combined with cultural controls, surveillance and threshold-based decision making. This integrated approach improves reliability and prevents ecological imbalance by avoiding over-reliance on any single tactic. Farmers are trained to recognise beneficial insects, use traps and scouting data to time interventions, and apply biopesticides safely and only when necessary.

7.9 Chemical Controls (Last Resort)

Chemical pesticides are considered only when all other preventive, cultural, mechanical, and biological control methods have proven insufficient and when pest populations exceed established economic thresholds. Their use within the Adiabo AIH is strictly regulated to minimize risks to human health, non-target organisms, and the environment.

In line with the FAO/WHO International Code of Conduct on Pesticide Management, the PMP mandates the exclusion of all Highly Hazardous Pesticides (HHPs), including formulations classified by the World Health Organization (WHO) as Class Ia (extremely hazardous) and Class Ib (highly hazardous). Pesticides falling into WHO Class II (moderately hazardous) may only be considered under controlled, justified circumstances, subject to approval by NAFDAC and relevant regulatory authorities. Detail of the approved and banned pesticides in line FAO and WHO standard is presented in Annex A

Only NAFDAC-registered, low-toxicity formulations are permitted, with preference for products that degrade rapidly, pose minimal risk to pollinators and aquatic life, and have proven efficacy against target pests. Persistent Organic Pollutants (POPs), obsolete stocks, and non-registered formulations are strictly prohibited. Detail of the approved and banned pesticides in line FAO and WHO standard is presented in Annex A.

To further safeguard health and the environment:

- Application must be carried out by trained and certified personnel only.
- Mandatory use of Personal Protective Equipment (PPE) is required during mixing, loading, and spraying.
- Spraying should be performed under suitable weather conditions to minimize drift and off-target contamination.
- Detailed record keeping of products used, quantities applied, and application dates must be maintained.

This framework ensures that chemical control remains a last resort, deployed only when necessary, and aligned with AfDB safeguards, World Bank ESS3 requirements, and Nigeria's regulatory standards. The use of chemical pesticides is considered only when pest populations exceed established economic thresholds and no alternative options are feasible. Such approach will focus on:

- **Selection Criteria:** Only NAFDAC-approved, low-toxicity chemicals are permitted. Exclusion of Persistent Organic Pollutants (POPs) such as DDT, aldrin, lindane as per the Stockholm Convention.
- **Application Conditions:** Spraying only at early morning or late afternoon to reduce volatilisation and protect pollinators. Use of calibrated knapsack sprayers by trained personnel using complete PPE.
- **Record-Keeping:** Mandatory documentation of active ingredient, dosage, date, weather condition, and operator. This safeguards against overuse and supports future monitoring and traceability.

7.10 Thresholds & Decision-making:

Each pest has a pre-defined economic threshold beyond which management becomes necessary to prevent economic loss. Examples are shown in Table 8:

Table 8: Threshold and Decision-making

Crop	Pest	Threshold
Cassava	Mealybug	≥ 5 bugs per 10 leaves
Maize	Stem Borer	≥ 20 moths per trap/week
Legumes	Bruchids	> 5 beetles/kg of stored seed

Decision-making should be informed by:

- Weekly scouting data;
- Pest trend analysis on the PMP digital dashboard and
- Farmer feedback during routine extension visits

7.11 Monitoring & Adaptive Evaluation Continuous data-driven refinements:

Adaptive management ensures continuous learning and refinement of pest control strategies. Key actions include:

Post-Intervention Monitoring: Yields, pest resurgence, and residue analysis.

Farmer Feedback Surveys: To assess satisfaction, constraints, and indigenous practices. Review Workshops: Annual reflection sessions with stakeholders to adjust action thresholds, revise SOPs, and update pest profiles. This dynamic system supports iterative improvements and knowledge generation in line with FAO’s IPM evaluation protocols.

7.12 Post-Harvest Pest Management

This section sets out how the AIH will prevent, monitor and control storage pests and mycotoxin risks for rice, maize, groundnut, yam (chips/flour) and melon (egusi). It applies to on-farm stores, aggregation points and warehouses. The PMP operationalizes Integrated Pest Management (IPM) and full life-cycle pesticide stewardship in line with the FAO/WHO Code of Conduct on Pesticide Management, WHO hazard classification and Highly Hazardous Pesticide (HHP) guidance; the African Development Bank Integrated Safeguards System (ISS); and Nigerian law (NAFDAC and NESREA).

Cross River State’s warm, humid climate accelerates insect multiplication and mould growth in inadequately dried grain and oilseeds. Principal storage pests include internal feeders—rice/maize weevils (*Sitophilus oryzae/zeamais*), larger grain borer in maize (*Prostephanus truncatus*) and groundnut bruchid (*Caryedon serratus*)—and external feeders such as *Tribolium spp.* and moths

(*Plodia/Ephestia*). Yam chips are highly susceptible to *Dinoderus porcellus*. Aflatoxin risk is material in maize and groundnut if moisture and insect damage are not controlled.

The PMP adopts an IPM-first hierarchy and excludes WHO Class Ia/Ib actives; any Class II products are allowed only with enhanced controls. Only NAFDAC-registered products will be procured and used, with labels/SDS maintained on file. NESREA's 2023 Chemicals & Pesticides Regulations guide storage, transport and hazardous-waste handling under the Globally Harmonized System (GHS). Where national rules are silent, Good International Industry Practice (GIIP) in the AfDB OS 3 and WBG EHS Guidelines applies. Food safety controls align with SON/NAFDAC and Codex (CXS 193-1995) limits for mycotoxins.

Safe moisture content (MC) targets are the foundation of control: rice $\leq 14\%$ ($\leq 12\%$ for seed), maize $\leq 13\%$, groundnut pods $\approx 10\text{--}11\%$ and kernels $\approx 6\text{--}8\%$, yam chips/flour $\approx 10\text{--}13\%$, and melon (egusi) seed $\approx 6\text{--}8\%$. Lots above target are rejected for storage and redirected to drying. Practices include rapid post-harvest drying, cleanliness, proofing, palletization, stack plans, vegetation/rodent control and strict FIFO/FEFO.

Priority is given to sanitation, physical methods (sieving/aspiration, cold where available), and hermetic storage (triple-layer bags/liners and sealed silos) once grain is dry. Hermetic systems suppress insects by oxygen depletion and help stabilize moisture; modified atmospheres (CO_2/N_2) are used for high-value lots where feasible. Botanicals and inert materials (e.g., diatomaceous earth) are applied only where registered and labelled.

Chemical measures are considered only when monitoring shows escalating risk and non-chemical options are insufficient. Fumigation uses phosphine (aluminum/magnesium phosphide) delivered by licensed contractors in demonstrably gas-tight conditions with exposure monitoring, signage, exclusion zones and documented aeration/clearance; methyl bromide is not used. Residual/contact treatments are limited to empty-store applications where nationally registered, non-HHP and compatible with market specifications.

Every intake lot is checked for MC and visible defects. Warehouses implement a schedule of inspections—weekly in the first month then bi-weekly/monthly depending on season—using composite sieving, trap counts (probe/pitfall/pheromone), and temperature probing. Any live internal feeders trigger immediate segregation and hermetic transfer; rising external-feeder trends prompt sanitation and rotation; localized hotspots are investigated; and maize/groundnut lots with risk factors are screened for aflatoxin at intake and periodically.

Worker exposure to phosphine is managed to internationally recognized limits—0.3 ppm (8-h TWA) and 1 ppm (15-min STEL)—with calibrated gas meters, self-contained breathing apparatus (SCBA) on site, permit-to-work, and re-entry only after clearance certificates confirm ≤ 0.3 ppm. Community health and safety measures include advance notices, cordons, security, ventilation

protocols and a documented emergency response plan, consistent with WBG EHS and AfDB OS 3.

The SAPZ PIU (E&S) oversees compliance, budgeting and audits. Warehouse Managers implement drying, sanitation, hermetic handling and record-keeping. Certified fumigation contractors plan and execute treatments with exposure monitoring and incident reporting. The Quality/Food Safety team manages mycotoxin testing and segregation; the Extension team trains out growers on drying and hermetic practices. Records include intake QC sheets, MC/temperature logs, trap logs, fumigation plans and clearance certificates, and mycotoxin test reports.

Key metrics are: $\geq 95\%$ of lots meeting MC targets at intake; $\geq 90\%$ inspections completed on schedule; zero live internal feeders in finished goods; $\geq 80\%$ of at-risk maize/groundnut stored hermetically; $\geq 98\%$ aflatoxin compliance; and 100% of fumigations with gas-tightness verification and re-entry clearance.

The PMP is designed to cut quantitative and qualitative storage losses, meet national and export food-safety specifications, and eliminate serious safety incidents, while reducing reliance on hazardous pesticides. By embedding IPM, hermetic systems, verified fumigation practice and lender-grade EHS controls, the AIH, Adiabo will achieve durable compliance with FAO/WHO guidance, the World Bank and AfDB safeguards, and Nigerian regulations, and deliver safer, higher-quality commodities to market. Table 9 Shows the Standards and Compliance Framework Alignment and how they apply.

Table 9: Standards and Compliance Framework Alignment

Standard / Instrument	Key Requirement	Where addressed
FAO/WHO Code of Conduct on Pesticide Management (2014)	IPM-first; lifecycle stewardship; avoid Highly Hazardous Pesticides (HHPs).	Sections 6, 8, 10, 11; Annex References
WHO Recommended Classification of Pesticides by Hazard (2019)	Screen actives; exclude Ia/Ib; strengthened controls for II.	Sections 6, 8; Roles & Responsibilities
FAO/WHO Guidance on Highly Hazardous Pesticides (2016)	Identify and phase-out HHPs where feasible.	Sections 6–8; Procurement & Screening
World Bank ESF (ESS3) & OP 4.09 (Pest Management)	Promote IPM; PMP when pesticides are financed; protect workers/community.	Sections 5–12; Monitoring & M&E
WBG EHS Guidelines (General; Agribusiness & Food Production)	GIIP for storage, fumigation, OHS and emissions.	Sections 6, 8, 10–12
AfDB Integrated Safeguards System (ISS) (OS-1/3/4/5)	E&S assessment; resource mgt; hazardous materials; OHS.	Sections 2, 8–12; Roles & Responsibilities
Nigeria: NAFDAC Pesticide Regulations & Guidelines (+ 2024 biopesticides)	Only NAFDAC-registered products; proper labelling; bans/permits.	Sections 6, 8, 10; Annex References

Nigeria: NESREA Chemicals & Pesticides Regulations (2023)	GHS labelling; storage/handling; restricted lists; waste.	Sections 6, 8, 10, 11
Aflatoxin standards (SON/NAFDAC; Codex)	Meet national and export limits for maize/groundnut.	Section 7; Monitoring & Testing

These translate global and Nigerian instruments into day-to-day controls. In SAPZ operations this means: (i) prioritizing Integrated Pest Management (IPM) and avoiding Highly Hazardous Pesticides (HHPs); (ii) using only NAFDAC-registered products with compliant labelling; (iii) following Good International Industry Practice (GIIP) for fumigation and warehouse safety; and (iv) documenting decisions, training and monitoring (evidence for lenders’ E&S reviews).

Storage Ecology and Risk Drivers

The warm, humid climate of Cross River State promotes rapid insect multiplication and mould growth where grain or seeds are stored above safe moisture content (MC). Internal feeders (*Sitophilus spp.*, larger grain borer *Prostephanus truncatus*) are especially damaging, while external feeders (*Tribolium spp.*) and moths (*Plodia/Ephestia*) cause contamination and quality loss. Hermetic systems suppress insect development by oxygen depletion and help stabilise moisture.

Crop-by-Crop Risk Profile and Targets

Table 10 shows safe moisture content (MC) targets in rice, maize, groundnuts, yam and melon.

Table 10: Safe Moisture Content (MC) Targets

Crop	Safe Moisture Target	Notes
Rice (paddy/milled)	≤14% MC (≤12% for seed)	IRRI postharvest guidance; lower MC prolongs shelf-life.
Maize	≤13% MC	FAO grain storage guidance emphasizes MC as the critical factor.
Groundnut (unshelled pods)	≈10–11% MC	Store drier if shelled; protect from rain and high RH.
Groundnut (shelled kernels)	≈6–8% MC	Oilseed kernels require lower MC to deter rancidity/moulds.
Yam (chips/flour)	≈10–13% MC	Deep drying via thin slicing; store insect-proof; rotate stock.
Melon (egusi) seed	≈6–8% MC	Oilseed; dry, cool storage needed for quality/viability.

Safe Moisture Content (MC) Targets

Rationale: insects and moulds proliferate when grain is stored above its safe moisture level, especially in humid Cross River conditions. Targets derive from FAO/IRRI post-harvest guidance and oilseed handling practice. Lower MC is required for oilseeds (groundnut, melon) to deter rancidity and mould; seed lots require lower MC for viability. IRRI and FAO guidance consistently cite $\leq 14\%$ for rice grain and lower thresholds for seed; FAO grain storage notes emphasizes moisture as the single most critical factor for safe storage. Table 11 shows **key storage pests and signs of infestation**.

Table 11: Key Storage Pests and Signs

Crop(s)	Principal Storage Pests	Signs of Damage
Rice	<i>Sitophilus oryzae</i> (rice weevil)	Emergence holes, dusty frass, live adults on sieving.
Maize	<i>Sitophilus zeamais</i> ; <i>Prostephanus truncatus</i> (LGB); <i>Tribolium spp.</i>	Kernel cavities, heavy flouring; LGB frass and heat build-up.
Groundnut	<i>Caryedon serratus</i> (groundnut bruchid); <i>Tribolium spp.</i> ; <i>Trogoderma granarium</i>	Oviposition on pods; grub tunnelling; powdery residues; kernel loss.
Yam (chips/flour)	<i>Dinoderus porcellus</i> (yam chip beetle)	Pin-holes, internal tunnelling; weight loss of chips.
Melon (egusi) seed	<i>Tribolium spp.</i> ; <i>Plodia/Ephestia</i> moths; storage moulds	Off-odours; webbing; fines; caking; visible fungal growth if MC too high.

Internal feeders (*Sitophilus spp.*; *Prostephanus truncatus*; *Caryedon serratus*) cause hidden losses and require immediate segregation and hermetic treatment or fumigation. External feeders (*Tribolium spp.*), moths (*Plodia/Ephestia*) and moulds mainly reduce quality, create hot spots and contaminate lots. The management implication of any live internal feeders warrants immediate segregation and hermetic transfer; evaluate certified fumigation only after gas-tightness is confirmed and non-chemical options are exhausted.

Monitoring, Inspection and Thresholds

Table 12 presents the proposed Stored Produce Monitoring Protocol:

- Use deep-bin triers or vacuum probes for bulk and composite sampling for bagged lots.
- Inspect by sieving (1–2 kg composites), visual checks and pitfall/probe traps.
- Record live insects per kg, species, MC and temperature.

- Frequencies: intake for every lot; weekly for the first month; bi-weekly during warm/rainy periods; monthly otherwise.

Table 12: Stored Produce Monitoring Protocol

Task	Method	Minimum Frequency	Records
Moisture check	Calibrated meter	Every lot at intake; per inspection round	%MC; date; device ID
Insect detection	Sieve 1–2 kg composite; crack-out	Per inspection round	Species; counts/kg
Trapping	WB/probe/pitfall traps	Weekly (first month), then bi-weekly	Trap map; counts
Temperature	Probe thermometers	Per inspection round	°C per stack/bin
Aflatoxin risk (maize/groundnut)	Rapid test (ELISA) for high-risk lots	At intake and quarterly	µg/kg; lot ID

Internal feeders (*Sitophilus spp.*; *Prostephanus truncatus*; *Caryedon serratus*) cause hidden losses and require immediate segregation and hermetic treatment or fumigation. External feeders (*Tribolium spp.*), moths (*Plodia/Ephestia*) and moulds mainly reduce quality, create hot spots and contaminate lots. Segregate and transfer to hermetic; consider fumigation if warranted. For external feeders/moths, act on rising trap trends or >1–2 adults/kg in sieved composites.

Integrated Pest Management (IPM) Toolbox — Hierarchy of Controls

- Prevention & GSP: dry to target MC; sealed, clean stores; pallets; FIFO/FEFO; vegetation and rodent control.
- Hermetic storage: triple-layer bags/liners or sealed silos for maize, legumes and oilseeds once dry; avoid mid-season openings.
- Physical/biophysical: sieving/aspiration; cold storage where available; modified atmospheres (CO₂/N₂).
- Botanicals & inert materials: approved botanicals; diatomaceous earth for empty structures or as labelled.
- Chemical (last resort): phosphine fumigation only by licensed operators in gas-tight conditions with exposure monitoring and clearance; methyl bromide prohibited; residual sprays only for empty stores where registered and non-HHP.

Mycotoxin (Aflatoxin) Management for Maize & Groundnut

- Prevention: meet MC targets; protect from insects; maintain dry, cool conditions.

- Limits: follow SON/NAFDAC national limits and Codex maximum levels where export applies; test high-risk lots at intake and periodically in store.
- Non-conforming lots: segregate; consider processing/diversion routes; implement supplier CAPA.

Safe Use of Pesticides and Fumigants

Apply FAO/WHO Code, WHO hazard classes and HHP guidance; AfDB OS 3; WBG EHS and ESS 3; NAFDAC/NESREA rules. Phosphine exposure limits: 0.3 ppm (8-h TWA) and 1 ppm STEL; verify gas-tightness; monitor air; SCBA available; post DANGER—FUMIGATION signage; re-entry only after clearance. Handle residues/waste per regulations. Methyl bromide is banned for such uses in Nigeria. Table 13 sets out the roles and responsibilities for the storage pest management.

Table 13: Roles and Responsibilities

Role	Core Responsibilities
SAPZ PIU (E&S)	Approve PMP/SOPs; ensure ISS/ESF & national compliance; budget; audits & training.
Warehouse Manager	Drying/MC checks; sanitation; hermetic handling; inspections; records; triggers.
Certified Fumigation Contractor	Plan & execute; exposure monitoring; waste; incidents; NAFDAC/NESREA compliance.
Quality/Food Safety Team	Aflatoxin testing; segregation; supplier CAPA; SON/NAFDAC/Codex compliance.
Extension/Out grower Liaison	Farmer training on drying & handling; hermetic bags; traceability.

Each role has control duties and required evidence. The PIU oversees compliance and budget; warehouse managers implement drying, sanitation, hermetic handling and records; certified fumigators plan and execute treatments with exposure monitoring; the quality team owns aflatoxin testing and segregation; the extension team trains growers on drying and hermetic use.

Implementation Tables

The intake & storage control checklist and the pest incident response matrix are presented in Table 14 and Table 15 respectively.

Table 14: Intake & Storage Control Checklist

Step	Rice	Maize	Groundnut	Yam (chips/flour)	Melon (egusi) seed
Drying target (MC)	≤14% (≤12% seed)	≤13%	Pods 10–11%; kernels 6–8%	≈10–13%	≈6–8%
Cleanlines	Remove chaff; reject mouldy lots	Remove fines; reject mouldy	Avoid damaged kernels; keep dry	Chips fully dried; reject damp pieces	Clean seed; remove broken/damaged
Packaging /storage	Hermetic liners/bags; pallets	Hermetic or sealed silos	Pods in shell preferred; hermetic for kernels	Bug-tight bins; dry rooms	Hermetic or tight containers
Monitoring	Weekly→bi-weekly; traps & sieving	Same	Same; watch bruchid signs	Check for D. porcellus holes	Watch for webbing & fines
Actions if pests found	Segregate; hermetic; fumigate if necessary	As left	Hermetic; fumigate if high	Heat/cold or fumigate stacks	Hermetic; sanitation; targeted control

Each role has control duties and required evidence. The PIU oversees compliance and budget; warehouse managers implement drying, sanitation, hermetic handling and records; certified fumigators plan and execute treatments with exposure monitoring; the quality team owns aflatoxin testing and segregation; the extension team trains growers on drying and hermetic use.

Table 15: Pest Incident Response Matrix

Situation	Immediate Action	Follow-up
Internal feeders detected (any live)	Segregate; re-dry; hermetic; evaluate fumigation	Root-cause (MC/sanitation); enhance monitoring
External feeders increasing	Sanitation blitz; rotate stacks; local treatment or hermetic transfer	Review trap layout; tighten intake criteria
LGB hotspot (maize)	Gas-tight treatment; certified phosphine fumigation	Strengthen sealing integrity programme
Aflatoxin risk (screen fail)	Segregate; processing/diversion routes	Supplier CAPA; review drying/storage SOPs

The matrix escalates responses according to risk level: internal feeders → immediate segregation/hermetic and possible fumigation; external feeders → sanitation and hermetic transfer; LGB hotspots → certified fumigation in gas-tight conditions; aflatoxin screen failures → segregation and diversion with supplier CAPA.

Training, Communication and Documentation

Training: IPM; pest ID; drying/MC; sampling/trapping; hermetic handling; fumigation safety (exposure limits, meters, SCBA, signage); hazardous-waste handling; incident reporting. Records: lot intake, MC logs, inspection/trap logs, fumigation plans & clearance certificates, aflatoxin test records. Community notices apply during fumigation (WBG EHS). The M&E indicators are presented in Table 16.

Table 16: Monitoring and Evaluation (M&E) Indicators

Indicator	Target
% Lots meeting MC targets at intake	≥95%
% Inspections completed on schedule	≥90%
Live internal feeders in finished goods	Zero
Use of hermetic for high-risk lots (maize/groundnut)	≥80%
Aflatoxin compliance rate	≥98% lots within SON/NAFDAC limits
Fumigation incidents	Zero injuries; 100% clearance certificates

8 PRODUCTIVITY AND SUSTAINABILITY BENEFITS OF PEST MANAGEMENT OPTIONS

8.1 Introduction

A central question for the AIH PMP is how different pest-management strategies perform against productivity and sustainability goals. This chapter assesses three realistic options in the project context:

1. **Option A:** Sole use of Biological Pest Control (BPC) and Nature-Based Solutions (NBS);
2. **Option B:** Combination of BPC/NBS with proportionate, threshold-based chemical use (Integrated Pest Management);
3. **Option C:** Exclusive reliance on chemical control.

Each option is assessed against agreed criteria—agronomic performance, environmental impact, worker and community health and safety, economic performance, and institutional/social alignment—to support evidence-based decision-making.

8.2 Assessment Criteria

- i **Agronomic Effectiveness:** Ability to control key pests of cocoa, rice, cassava, yam, maize and legumes; yield stability; resilience to pest outbreaks.
- ii **Environmental Impact:** Effects on soil health, biodiversity, water quality and non-target organisms.
- iii **Worker's and Community Health and Safety:** Exposure risks, accident potential, food-residue compliance, public-health co-benefits.
- iv **Economic Performance:** Costs of inputs, labour, yield impact, market access, long-term cost efficiency.
- v **Institutional and Social Considerations:** Alignment with national policy, AfDB Operational Safeguards, NAFDAC registration, and community acceptance/ownership.

8.3 Option A — Sole Use of BPC/NBS

Agronomic Effectiveness

Exclusive use of BPC/NBS leverages natural enemies, habitat management, resistant varieties, intercropping, botanicals and microbial agents. In Nigeria, these measures have shown yield gains of 5–25% over no control, especially where practices are consistently applied. However, they may

be slower to suppress sudden, high-density pest outbreaks (e.g. fall armyworm surges), and efficacy can vary with weather and agent availability.

Environmental Impact

This option scores highest for environmental protection. It minimises pesticide residues, preserves pollinators and soil organisms, protects watercourses and maintains ecological resilience.

Worker and Community Health and Safety

Risks of acute or chronic chemical exposure are virtually eliminated. Botanicals and biopesticides are low-toxicity; conservation measures pose no risk. Public-health co-benefits include reduced vector-breeding habitats.

Economic Performance

Input costs are low; most measures use local materials. Labour requirements can be higher (pruning, weeding, manual scouting). Because outbreaks may take longer to suppress, yield losses can occur if scouting and response are not timely.

Institutional and Social Considerations

Fully aligned with Nigerian Integrated Pest Management Policy and AfDB Operational Safeguards. Likely high community acceptance because practices build on traditional methods. Requires strong extension and coordination to be reliable at scale.

8.4 Option B — Combination of BPC/NBS with Proportionate Chemical Use (Integrated Pest Management)

Agronomic Effectiveness

This is the approach recommended in the PMP. Biological and cultural practices are the first line of defence; low-toxicity pesticides are used only when economic thresholds are exceeded. Nigerian field experience shows yield gains of 15–40% with fewer spray rounds compared to conventional chemical programmes, plus better long-term suppression due to preserved natural enemies.

Environmental Impact

Substantially lower than full chemical use. Strategic, limited pesticide applications reduce residues and protect beneficial organisms, while BPC/NBS maintain ecological services.

Worker and Community Health and Safety

Exposure risk is significantly reduced compared with exclusive chemical use because the number of spray rounds is lower, products are selected for low toxicity, and PPE and training are included in the PMP. Compliance with residue limits for food and export standards is easier to maintain.

Economic Performance

This option has the most favourable cost–benefit ratio: higher yields than BPC/NBS alone, reduced chemical costs compared to conventional programmes, and better market acceptance. Initial training and coordination costs are offset by savings in inputs and improved quality premiums.

Institutional and Social Considerations

Directly aligned with national IPM and pesticide-management guidelines and AfDB OS3. Builds on community familiarity with both cultural and chemical methods, easing adoption. Requires moderate investment in training and monitoring systems.

8.5 Option C — Exclusive Chemical Control

Agronomic Effectiveness

Provides rapid knock-down of pest populations and initially high yield protection. However, continuous use of broad-spectrum pesticides accelerates resistance, can cause pest resurgence, and undermines long-term efficacy. In Nigeria, farmers using only chemicals have reported increasing spray frequencies and declining control over time.

Environmental Impact

Highest risk: soil and water contamination, harm to pollinators and aquatic life, reduced biodiversity and ecosystem services. Buffer zones and mitigation measures would be difficult to enforce at smallholder scale.

Worker and Community Health and Safety

Highest risk of acute and chronic pesticide exposure, including spray drift into neighbouring communities. Greater likelihood of exceeding national residue standards and jeopardising export certification. Increased risk of accidents and poisoning incidents without strict oversight.

Economic Performance

High recurrent input costs (pesticides, sprayers, PPE, disposal) with diminishing returns due to resistance. Market access can be lost if residue limits are exceeded. Any cost advantage from rapid action is offset by health, environmental and reputation costs.

Institutional and Social Considerations

Out of step with Nigeria’s IPM policy and AfDB safeguards. Likely to face community opposition and regulatory scrutiny. Generates hazardous waste and disposal obligations that are costly to manage.

8.6 Comparative Analysis of the Three Options

To guide decision-making for pest management at the AIH, the three strategic options described above were assessed side-by-side using the agreed criteria—agronomic effectiveness, environmental impact, worker and community health and safety, economic performance, and institutional/social alignment. This comparative analysis provides a clear picture of how each option performs under local conditions and highlights the trade-offs involved. The summary table distils the key findings, showing where each option is strongest and where it presents risks or limitations (Table 10). This enables project managers, farmers and stakeholders to choose the most appropriate strategy for balancing productivity with sustainability.

Table 10: Comparative Analysis of the Three Options

Criterion	Option A: Sole BPC/NBS	Option B: BPC/NBS + Proportionate Chemicals	Option C: Exclusive Chemicals
Agronomic effectiveness	Moderate, depends on consistency; slower response to outbreaks	High, stable yields; preserves natural enemies	Initially high, but declines with resistance and resurgence
Environmental impact	Very low	Low–moderate	High (soil, water, biodiversity loss)
Worker & community health/safety	Very low risk	Low risk with PPE & training	High risk (exposure, residues)
Economic performance	Low input cost, higher labour; possible yield risk	Best cost–benefit; higher yields & lower chemical costs	High input costs, market/residue risks
Institutional/social alignment	Strongly aligned with policy; high acceptance	Fully aligned with IPM policy; good acceptance	Weak alignment; low acceptance; compliance issues

8.7 Recommendations for AIH

The comparative assessment in Section 6.6 shows clear differences in how the three pest-management options perform across agronomic, environmental, health, economic and institutional criteria. Drawing on these findings and on the realities of farming systems in Cross River State, this section sets out tailored recommendations for the AIH project. The recommendations aim to maximise productivity and quality while safeguarding environmental integrity, worker and community health, and long-term compliance with Nigerian regulations and AfDB Operational Safeguards.

- **Adopt Option B (Integrated Pest Management)** as the core approach. It offers the best balance between productivity and sustainability by combining BPC/NBS with proportionate, low-toxicity chemical use only when thresholds are exceeded.
- **Strengthen Option A elements** within Option B: build capacity for scouting, natural-enemy conservation, resistant varieties and hermetic storage so that chemical inputs remain minimal.

- **Avoid Option C (exclusive chemical control)** except for emergency situations under regulated, supervised conditions.
- **Institutionalise decision rules:** integrate the surveillance and GIS mapping system described in Chapter 3.4 so interventions are triggered at the right time.
- **Monitor and report:** use the PMP dashboard to track adoption rates, pest trends, spray rounds, environmental incidents and worker health indicators.

The assessment shows that exclusive biological and nature-based solutions are environmentally safest but may underperform during outbreaks, while exclusive chemical control provides short-term knock-down but carries escalating costs, health risks and regulatory non-compliance. The combined IPM approach recommended in the PMP aligns with Nigerian and AfDB policies, delivers the best cost–benefit ratio, protects workers and communities, and maintains market credibility. Embedding this approach across AIH’s value chains will provide the foundation for both high productivity and long-term sustainability.

9 HEALTH, ENVIRONMENTAL AND SAFETY CONSIDERATIONS

Safe, environmentally responsible pest management is a prerequisite for the success of the Agro-Industrial Hub (AIH) in Adiabo, Odukpani LGA, Cross River State. The Hub will aggregate and process cocoa, rice, cassava, yam, maize and legumes from hundreds of smallholder suppliers. Without a robust health, environmental and safety system, the very practices designed to protect crops could expose workers, surrounding communities and ecosystems to unacceptable risk. This chapter therefore sets out a comprehensive framework for hazard identification, regulatory compliance, worker and community protection, safe pesticide handling, emergency preparedness, waste management, record-keeping and continuous improvement. It draws on existing practices in Cross River, fills gaps identified during stakeholder consultations and aligns fully with Nigerian regulations, AfDB Operational Safeguards (OS 3), FAO/WHO International Code of Conduct on Pesticide Management, and FMEnv guidelines.

9.1 Hazard Identification: Risk of Exposure and Health Effects

Before pest-control activities begin, it is essential to understand what hazards exist at the AIH and its supply farms. Field surveys undertaken for the PMP show that many farmers around Adiabo handle pesticides without adequate risk assessment. In the new PMP, every product proposed for use on AIH supply chains will be screened before procurement:

- **Hazard Profile:** Toxicity class (WHO/FAO), active ingredient, formulation, persistence, bioaccumulation potential.
- **Exposure Routes:** Inhalation of spray mist during application in cocoa plots; dermal contact when mixing neem-based sprays in rice paddies; accidental ingestion by children when containers are not secured.
- **Health Effects:** Acute poisoning (eye irritation, headaches, dizziness, nausea), chronic effects (neurological, reproductive, endocrine).
- **Ecological Effects:** Non-target organisms such as pollinators, aquatic insects in the Calabar River and beneficial predators in cassava and maize plots.

For each crop, a “hazard sheet” will be developed and posted in local language at input stores and training centres so that farmers and workers understand the risks and protective measures before use.

9.2 Legal and Regulatory Compliance

The AIH operates within a dense framework of Nigerian and international regulations on pesticide management. The PMP consolidates all legal requirements into a single compliance framework:

- i NAFDAC Registration: Only pesticides and biopesticides listed on the current NAFDAC register will be procured by the AIH.

- ii Federal Ministry of Environment/NESREA: Hazardous chemicals and waste regulations guide storage, transport and disposal.
- iii FAO/WHO International Code of Conduct: The AIH commits to this code, including provisions on highly hazardous pesticides and proper labelling.
- iv AfDB Operational Safeguards (OS3): Pollution prevention, hazardous materials management and emergency preparedness measures are fully integrated.
- v Cross River State By-laws: Local public-health and environmental regulations on chemical storage and open burning are enforced.

A compliance officer within the AIH management unit will keep a register of approved products, licences, SDS, and disposal certificates, and will submit annual compliance reports to NAFDAC, FMEnv and AfDB.

9.3 Worker's and Community Health and Safety

Protecting those who apply pest controls and those who live near treated fields is a core PMP objective. This subsection introduces the approach for safeguarding workers and communities, structured around the hierarchy of controls. It explains how the AIH will use elimination/substitution, engineering and administrative measures, training, medical surveillance and PPE to minimise risks at every step.

Hierarchy of Controls

The PMP for AIH follows the hierarchy of controls:

1. **Elimination/Substitution:** Highly hazardous pesticides (WHO Class Ia and Ib) are banned. Neem, Bt and other low-toxicity agents are preferred.
2. **Engineering Controls:** Vegetated buffer strips between sprayed plots and watercourses; designated mixing and washing areas with sumps.
3. **Administrative Controls:** Training, medical surveillance, job rotation, community notifications.
4. **PPE:** Used as the last barrier.

Administrative Controls

All farmers and workers supplying or employed by AIH will receive induction training on hazard recognition, label reading, calibration, spill control and first aid. High-exposure tasks (mixing concentrates, filling knapsack sprayers) will be rotated to limit cumulative risk. Health checks will be conducted twice yearly for applicators, focusing on cholinesterase levels for organophosphates. Community announcements will be made before spray operations, and buffer zones will be respected around schools, clinics and streams.

Mandatory Use of Personal Protective Equipment (PPE)

AIH will procure and distribute PPE tailored to the products being applied. Training covers correct donning/doffing, cleaning and replacement. A PPE replacement schedule will be budgeted annually. All pesticide handlers must use appropriate PPE, which includes:

- Nitrile gloves
- Respirators or face masks
- Long-sleeved overalls
- Safety boots
- Eye protection (goggles or face shields)

According to WHO (2022), improper handling of pesticides in Africa is responsible for over 25 million cases of pesticide poisoning annually, with many unreported in rural areas.

9.4 Pesticide Handling and Storage

The AIH site will have a central pesticide store built to Nigerian and FAO specifications:

- i All pesticides must be stored in lockable facilities,, ventilated, impervious floors with spill-containment.
- ii Shelving will segregate liquids from solids and incompatible products.
- iii Clear signage in English and local languages will restrict access to authorised personnel.
- iv No food, feed or drinking water may be stored in the same building.
- v An inventory control system (“first-in, first-out”) will prevent obsolete stockpiling.
- vi Only certified agro-dealers may supply pesticides, and community training shall emphasize correct dosage, mixing, and disposal.

9.5 Safe Application of Pesticides

Only trained and certified operators will be permitted to mix and apply pesticides. Sprayers will be calibrated before each use to avoid over-application and drift. Pre-harvest intervals and buffer zones will be strictly observed. Application will take place in early morning or late afternoon under low-wind conditions to protect pollinators and communities. For aerial or tractor-mounted applications (if any), drift-reduction nozzles and GPS mapping will be used. Each application will be logged with product, quantity, applicator, date and location.

9.6 Emergency Preparedness and Response

Accidents, spills and extreme events can occur despite precautions. This subsection introduces the AIH’s emergency preparedness framework plans, equipment, contacts and drills to ensure rapid, effective response to protect people and the environment when something goes wrong. A written emergency plan will be displayed in storage and mixing areas. It will cover:

- spill containment and neutralisation;
- accidental human exposure, with contact details of local health facilities;
- fire (including firefighting procedures and compatible extinguishers);
- extreme weather events that could cause flooding of storage areas.

Spill kits, eye-wash stations, first-aid boxes and emergency showers will be provided. Annual mock drills will test staff readiness and improve procedures.

9.7 Waste Disposal and Environmental Safety

Empty containers will be triple-rinsed, punctured and returned to designated collection points at the AIH. Contracts will be established with licensed recyclers or hazardous-waste handlers approved by NAFDAC and FMEnv. Open burning or burial is prohibited. Berms and vegetated buffer strips will prevent run-off into Adiabo streams and wetlands. Any obsolete pesticide discovered in the supply chain will be documented and disposed of safely in collaboration with national authorities.

9.8 Environmental Safeguards

Protecting biodiversity, soil health, and aquatic ecosystems from agrochemical contamination is a critical component of the PMP. Specific provisions include:

Buffer Zones: Mandatory buffer strips (10–30 metres) must be maintained between treated fields and:

- Rivers, streams, wetlands.
- Community wells and water tanks.
- School farms and livestock pens.

These measures help prevent drift, runoff, and leaching of pesticides into ecologically sensitive zones.

Banned Substances: Absolute ban on use of Persistent Organic Pollutants (POPs), including: DDT, aldrin, dieldrin, lindane, and chlordane.

Any pesticide not approved by NAFDAC, FMEnv, or Stockholm Convention lists

Annexes A, B (SOP for surveillance - sample from UC Davis logistics applied contextually), C (Training modules outline (IPM principles, SOPs, safety), D (Institutional contact directory) and E (Relevant regulatory and international standards, including IPM definitions and framework) of this PMP provides a full list of prohibited substances in Nigeria as of 2025.

Safe Disposal Protocols: Triple rinsing and puncturing of used containers before disposal. Disposal through state-recognized hazardous waste facilities or high-temperature incineration units. No burial or burning of pesticide containers on-farm

Environmental Monitoring: The Ministry of Environment, in liaison with NESREA, shall:

- Conduct quarterly soil and water residue tests in hotspot areas.
- Publish findings in the SAPZ environmental bulletin for transparency.

These actions are consistent with Nigeria’s National Environmental (Agrochemical) Regulations, 2009.

9.9 Community and Ecosystem Considerations:

Beyond immediate health impacts, pest management can affect food safety, pollinators, and the broader agro-ecosystem. Therefore:

Pollinator Protection: Avoid pesticide application during flowering stages. Promote bee-friendly pest control techniques such as botanical extracts.

Food Chain Safeguards: Pesticide application must observe pre-harvest intervals (PHIs) to prevent residue contamination in food sold within the SAPZ.

Livestock Exposure: Livestock should not graze on sprayed fields for at least 10 days post-application.

Extension agents must routinely sensitize herders and livestock farmers about spray schedules as shown in Table 17.

Table 17: Summary of Health & Environmental Safeguards

Area	Requirement	Responsible Agency
PPE Use	Gloves, respirators, overalls	Federal Ministry of Agriculture & ADP
Pesticide Storage	Ventilated, secure, away from homes	Federal Ministry of Environment
Buffer Zones	10–30m from water and residential areas	Federal Ministry of Environment
Banned Chemicals	No POPs or unregistered products	NAFDAC & NESREA
Container Disposal	Triple rinse, incinerate or deliver to safe sites	State Waste Agencies
Water Testing	Quarterly residue analysis	NESREA & Federal MoEnv
Pollinator Protection	Avoid sprays during flowering	Extension Workers

9.10 Record Keeping and Documentation

Transparent records are the backbone of regulatory compliance and continuous improvement. AIH will maintain centralised logs of product use, training, incidents and approvals, ensuring traceability and accountability across the pest-management system. The PMP establishes a central database at the AIH capturing:

- all pesticide purchases, distribution and use by crop and location;
- training attendance and health-surveillance records;
- incident and spill reports and corrective actions;
- SDS and regulatory approvals for each product.

Records will be maintained for at least five years and made available to regulators and AfDB supervision missions.

9.11 Monitoring and Continuous Improvement

A PMP must evolve as conditions and risks change. This subsection explains how the AIH will inspect, sample and review its pest-management practices regularly, use feedback from workers and communities, and update training and procedures to achieve continual improvement in health, environmental and safety performance.

Cross River ADP extension agents and AIH supervisors will conduct quarterly inspections of stores, handling and application practices. Periodic environmental sampling (soil and water) will check for contamination near storage and application sites. Worker and community feedback channels will identify emerging issues. An annual review of health, environmental and safety performance will be held; findings will feed into updated training modules and corrective action plans.

10 STAKEHOLDER ENGAGEMENT AND AWARENESS

Stakeholder engagement is a cornerstone of the PMP’s successful implementation. Integrated Pest Management (IPM) thrives not solely on technical accuracy but on inclusive participation, local ownership, and active feedback. This chapter outlines the engagement framework designed to ensure that farmers, institutions, academia, agro-processors, NGOs, and the wider public are meaningfully involved in pest management planning, execution, and monitoring in the AIH project.

In alignment with the AfDB’s OS 10 and FAO’s participatory IPM model, the PMP adopts a multi-stakeholder engagement approach that prioritizes transparency, inclusivity, and responsiveness throughout the lifecycle of the AIH project.

10.1 Engagement Plan

Inclusive workshops, field days, local-language radio broadcasts; Engaging women and youth in extension efforts; Feedback loops via farmer groups and steering committee liaison.

10.2 Stakeholder Identification and Roles

A stakeholder mapping exercise was undertaken to categorize actors based on their influence, interest, and role in pest management as presented Table 18.

Table 18: Stakeholder Identification and Roles

Stakeholder Group	Role in PMP Implementation
Smallholder Farmers	Primary adopters and informants of pest dynamics
Agro-Processors	Ensure pest-free raw material supply from out-growers
Women and Youth Groups	Serve as change agents, field scouts, and FFS trainers
Traditional Rulers	Support community mobilization and land-use norms
NGOs/CSOs	IPM training, advocacy, and environmental monitoring
UNICROSS/ Research Institutions	Design pest control packages and biocontrol studies
Government Ministries	Policy enforcement, extension services, and regulation
Development Partners (AfDB, FAO)	Technical and financial support

This multi-actor constellation ensures that pest management is informed by indigenous knowledge, scientific evidence, and public interest considerations.

10.3 Engagement Methods

To ensure broad-based participation and behavioural change, the following communication and engagement methods will be employed:

Workshops and Consultations: Initial sensitization sessions in all 10 AIH project wards; Periodic review forums (quarterly and annual) and Gender-sensitive group discussions to amplify voices of women and youth

Field Days and Demonstrations: Visual demonstration of IPM practices (e.g., trap placement, PPE usage, hand-picking pests) and Showcase success stories from lead farmers and early adopters

Mass Communication

- **Local Radio Campaigns:** Pest alerts, safe use of pesticides, call-in sessions
- **Drama and Folk Media:** Use of traditional theatre to spread messages in Efik dialect
- **Information, Education & Communication (IEC) Materials:** Posters, flyers, and training manuals in English and local languages; Visual guides for illiterate farmers on storage hygiene, pest identification, and biocontrol agents

Digital Feedback Mechanisms

- Interactive SMS short codes for pest reporting and queries; Voice-based platforms for semi-literate groups
- WhatsApp support groups for extension workers and community focal persons.

These approaches increase awareness, demystify pest management practices, and establish communication feedback loops for timely decision-making.

10.4 Inclusion and Equity Strategy

Inclusive engagement is a priority for this PMP. Special attention will be given to marginalized and vulnerable groups to ensure equitable access to pest control resources and knowledge.

Gender Mainstreaming

Minimum 40% female representation in all training activities; Targeting female-led farms in surveillance efforts and biocontrol usage and Collaboration with Cross River State Ministry of Women Affairs

Youth Empowerment

- Training of rural youth as IPM Scouts and Pest Surveillance Officers
- Linkage with youth-based agropreneurship hubs for pesticide retailing and advisory services.

Social Safeguards

Cultural considerations in pesticide storage and application (e.g., excluding child labour) and Dispute resolution mechanisms integrated into CR-SAPZ grievance redress systems (Table 19; SEP refers).

10.5 Engagement Schedule and Responsibilities

Table 19: Activity frequency and lead institutions

Activity	Frequency	Lead Institution
Stakeholder Sensitization	Biannually	Ministry of Agriculture & Irrigation Development
Radio Pest Alerts	Weekly (growing season)	ADP + Local FM Stations FM Stations
Community Demonstration Days	Quarterly	ADP + NGOs
IPM WhatsApp Forums	Continuous	ADP Extension Desk
Annual Stakeholder Review Forum	Annually	SAPZ Steering Committee

10.6 Monitoring Stakeholder Engagement

An Engagement Monitoring Matrix will track: Number of stakeholders reached (disaggregated by gender and youth); Engagement method used; Satisfaction scores (via post-activity feedback forms); Incorporation of feedback into PMP revisions. Results will be shared quarterly on the PMP digital dashboard and SAPZ bulletin board.

10.7 Stakeholder Engagement and Consultation Evidence

Stakeholder engagement is a cornerstone of the Pest Management Plan (PMP) for the Adiabo Agro-Industrial Hub (AIH). Clearly, the African Development Bank (AfDB) emphasised the need for evidence-based consultations during PMP preparation, including details of venues, dates, participants, documentation, grievance redress mechanisms (GRM), and costing in USD (United States of American Dollars). This section dwells on those requirements, presenting a thorough account of the consultative process undertaken in line with AfDB’s Integrated Safeguards System, the World Bank’s Environmental and Social Framework, and Nigeria’s participatory development norms.

Venues and Dates of Consultations

A series of multi-stakeholder consultations were convened between 15 May and 27 June 2025 in Cross River State. Key venues and dates included:

- i Initial sensitization meeting with with Local Government Council, farmers, cooperatives, and local leaders on 18 May, 2025 (Plate 1 and 2).
- ii Stakeholders Scoping Workshop, Calabar Municipal Local Government Area at the Hogis Hotel, State Housing, Calabar on 05 June 2025 (Plate 3).



Plate 1: (Right): Focused Group Meeting with Elders of Adiabo Ikot Mbo Otu and Adiabo Esine Ufot Communities at Adiabo Town Hall On 18.06.2025. Plate 2: (Left): Consultation Meeting with Leaders of Adiabo Ikot Mbo Otu and Adiabo Esine Ufot at Adiabo Town Hall on 18.06.2025



Plate 3: Cross sections of participants at the stakeholders engagement/scoping workshop (top left), NESREA Rep. making his contribution (top-middle); CR-SAPZ Rep. fielding questions from participants (top right); FMEnv. Rep sitting among other stakeholders at the workshop (down left), the FMEnv. Rep making addressing the workshop, surrounded by a representative of the Clan Head of Adiabo and reps of the Nigerian Navy, NSCDC, Customs, among other participants (down right)

Stakeholder Groups Consulted

The consultations covered a broad spectrum of stakeholders, reflecting the multidimensional nature of pest management. Stakeholder groups included:

- i Smallholder farmers (cassava, rice, maize, cocoa, vegetables)
- ii Women’s cooperatives and youth associations.
- iii Agro-dealers and private input suppliers.
- iv Extension officers from CRADP.
- v Representatives of NAFDAC, NAQS, NESREA, and the Ministry of Environment.

- vi Academia and research institutes (University of Calabar and University of Cross River State-UNICROSS,IITA).
 - vii Ministries, Departments and Agencies (MDAs).
 - viii Development partners (Representatives of AfDB and SAPZ).
- This diversity ensured that all interests, knowledge systems, and potential concerns were appropriately captured.

Documentation of Consultations

All consultations were formally documented to provide verifiable evidence to AfDB and other stakeholders. Documentation included:

- i Attendance registers with names, affiliations, and contact information
- ii Detailed minutes of proceedings.
- iii Photographic records of deliberations, group photographs, and presentations.
- iv Copies of workshop materials (PowerPoints, handouts, PMP fact sheets).
- v Summaries circulated to participants.

These documents will be annexed in the PMP and made available upon request to AfDB's safeguard team.

Grievance Mechanism (GM) Integration

The PMP integrates the grievance mechanism (GM) established under the Stakeholder Engagement Plan (SEP) for the Cross River SAPZ. The GM provides a structured, accessible, and transparent platform for stakeholders to raise concerns about pest management activities. Features of the GM include:

- i Multiple entry points: community meetings, suggestion boxes at AIH sites, SMS/WhatsApp hotlines.
- ii A three-tier resolution process: (i) community-level resolution by farmer committees; (ii) escalation to CRADP/IPM coordination unit; and (iii) referral to SAPZ grievance committee if unresolved.
- iii Defined timelines: acknowledgement within 48 hours, resolution within 30 days.
- iv Confidentiality and protection from retaliation.
- v Monitoring and reporting of grievance cases in quarterly PMP reports.

The GM ensures that farmer voices are central to PMP implementation, thereby enhancing accountability and trust.

Costing of Stakeholder Engagement in USD

Stakeholder engagement activities were costed to ensure transparency and resource adequacy. Costs are summarised as follows:

- i Community consultations (venue hire, logistics, refreshments): USD 12,000
- ii Technical workshops and roundtables: USD 18,000.
- iii Documentation (printing, translation, photography): USD 5,500.
- iv Grievance mechanism operations (hotlines, boxes, reporting tools): USD 7,500.

- v Monitoring and reporting (surveys, M&E staff): USD 6,000.
- vi **Total estimated cost: USD 49,000.**

These costs are integrated into the overall PMP budget and co-financed by AfDB project resources and Cross River State contributions.

The stakeholder engagement section demonstrates compliance with AfDB's requirements by providing evidence of venues, dates, stakeholder groups, documentation, integration of grievance mechanisms, and costing in USD. By embedding participatory approaches and transparency, the PMP ensures that pest management strategies are not only technically sound but also socially legitimate and inclusive. This process enhances the ownership, accountability, and long-term sustainability of pest management interventions under the Adiabo AIH SAPZ.

11 BUDGETING AND FINANCING

Budgeting and financing are pivotal to the successful implementation of this Pest Management Plan (PMP). A well-costed and sustainably funded plan ensures continuity, accountability, and scalability of pest control interventions. This chapter presents estimated costs, funding mechanisms, and financial accountability systems designed to align with international donor requirements and national budgetary frameworks.

The budgeting approach adopts the results-based financing (RBF) model promoted by the African Development Bank (AfDB) and World Bank, ensuring that expenditures are tied to verifiable outcomes in pest management.

11.1 Cost Estimates

A preliminary cost assessment was undertaken using activity-based costing principles. The budget is divided into five core components (Table 20, Table 21, Table 22, Table 23,

Table 24, and Table 25).

Table 20: Surveillance infrastructure

Item	Unit Cost (₦)	Quantity	Total (₦)	Unit Cost (\$) @ ₦1555/1\$	Total (₦)
Pheromone traps	8,000	120	960,000	5.14	617.36
Sticky traps	3,000	200	600,000	1.93	385.85
Mobile pest reporting devices	75,000	20	1,500,000	48.23	964.63
GIS mapping software & licenses	1,200,000	1	1,200,000	771.70	771.70
Subtotal			4,260,000	827	2,739.54

Training and Capacity Building

Table 21: Training and Capacity Building

Activity	Budget (₦)	Budget (\$) @ ₦1555/1\$
Farmer Field Schools (FFS) across 10 wards	2,500,000	1,608.36
IPM Training of Trainers (ToT) for 30 agents	1,800,000	1,157.77
Safety and PPE workshops	900,000	579.19
Training manuals (local languages)	500,000	321.54
Subtotal	5,700,000	3,666.86

Procurement of Inputs

Table 22: Procurement of Inputs

Item	Budget (₦)	Budget (\$) @ ₦1555/1\$
Biocontrol agents (e.g., <i>Trichogramma</i>)	2,000,000	1,286.02
Neem-based botanical pesticides	1,000,000	643.01
Personal Protective Equipment (PPE)	1,500,000	964.52
Storage sanitisation kits	800,000	515.21
Subtotal	5,300,000	3,408.76

Monitoring, Reporting & Evaluation (MRE)

Table 23: Monitoring, Reporting and Evaluation

Activity	Budget (₦)	Budget (\$) @ ₦1555/1\$
Field visits by supervisors (quarterly)	600,000	386.00
Printing of templates and data sheets	200,000	128.60
External mid-term evaluation	1,000,000	643.01
Annual review workshop	1,200,000	771.61
Subtotal	3,000,000	1,929.83

Public Engagement and Awareness

Table 24: Public Engagement Budget

Activity	Budget (₦)	Budget (\$) @ ₦1555/1\$
Radio jingles and talk shows (3 stations)	600,000	386.00
Stakeholder sensitization forums	900,000	579.19
Youth and women inclusion campaigns	500,000	321.54
Subtotal	2,000,000	1,286.02

Consolidated Budget Summary

Table 25: Consolidated Budget Summary

Component	Estimated Budget (₦)	Budget (\$) @ ₦1555/1\$
Surveillance Infrastructure	4,260,000	2,739.55
Capacity Building	5,700,000	3,666.85
Inputs Procurement	5,300,000	3,408.68
Monitoring & Evaluation	3,000,000	1,929.83
Awareness and Engagement	2,000,000	1,286.02
Contingency (10%)	2,420,000	1,556.59
Grand Total	22,680,000	14,587.52

Note: Budget estimates are indicative and shall be refined during implementation planning. All costs are based on 2025 market prices and subject to inflation adjustments and exchange rate fluctuations.

11.2 Funding Sources

The funding sources is the African Development Bank (AfDB). The AIH project, as part of the Cross River State cluster, benefits from the broader SAPZ funding structure described above. The initiative is backed primarily by development finance institutions (AfDB). Exact allocation specific to Adiabo are not publicly detailed, but it’s reasonable to attribute support to this cluster via Cross River’s inclusion in the eight state first phase and expanded phase two.

Note: Budget estimates are indicative and shall be refined during implementation planning. All costs are based on 2025 market prices and subject to inflation adjustments and exchange rate fluctuations.

12.1 Funding Sources and Disbursement

To ensure multi-source sustainability, the PMP shall be financed through a combination of:

- **SAPZ Development Fund:** Main project envelope co-financed by AfDB and the Federal Government of Nigeria. Pest management costs are embedded in the ESMP and infrastructure development budget lines.
- **State Ministry of Agriculture Allocations:** Annual state budgetary provisions under “Agricultural Health and Biosecurity”
- **Support from Development Partners: Contributions from:** World Bank Climate-Smart Agriculture Programme; FAO’s Technical Cooperation Programme (TCP) and International Institute of Tropical Agriculture (IITA) for biocontrol deployment.
- **Private Sector and PPPs:** Agro-processing companies operating within the SAPZ will be encouraged to co-finance pest management on out-grower farms under contract farming agreements.

11.4 Financial Management and Accountability

To uphold transparency and donor confidence:

- All expenditures will be managed through the AIH project Financial Management Unit (PFMU). Quarterly expenditure reports shall be submitted to: AfDB Country Office, Cross River State Auditor General and SAPZ Steering Committee.
- All disbursements must be traceable to activity plans and verified through field audits.

12 MONITORING AND EVALUATION

Monitoring and evaluation (M&E) constitute the backbone of adaptive pest management under the PMP. A dynamic feedback loop ensures that interventions are not only tracked and documented but are also regularly reviewed for effectiveness, efficiency, and alignment with evolving agro-ecological realities. This chapter outlines the M&E framework, performance indicators, reporting procedures, and review mechanisms in line with international guidelines, particularly those of the African Development Bank (AfDB) and FAO IPM programme evaluation standards.

12.1 Indicators for Performance Measurement

To assess progress and inform evidence-based decisions, the following key performance indicators (KPIs) are tracked at regular intervals (Table 26):

Table 26: Indicator performance Measures

Indicator	Unit of Measure	Data Source	Frequency	Responsible Institution
Pest incidence rate in major crops	% reduction in pest incidence	Field surveys, farmer reports	Quarterly	ADP, MoA
Volume of pesticides procured	Litres/kg	Agro-dealer reports, NAFDAC data	Quarterly	MoA, NAFDAC
Reduction in chemical pesticide use	% decrease compared to baseline	Farmer surveys, agro-dealer sales	Bi-annual	MoA, MoEnv, ADP
Farmers trained on IPM	Number trained	Training attendance, FFS records	Quarterly	MoA, ADP
Adoption of IPM practices	% of trained farmers adopting IPM	Field monitoring, extension reports	Bi-annual	ADP, MoA
Grievances resolved	% of grievances addressed	Grievance redress mechanism reports	Quarterly	SAPZ Steering Committee, MoA
Incidence of pesticide-related health issues	Number of cases	Health facility records	Bi-annual	MoH, MoA
Residue levels in soil and water	mg/kg, ppm	Laboratory analysis	Quarterly	MoEnv, NESREA
Compliance with PPE use during spraying	% applicators using PPE	Field inspections	Quarterly	ADP, MoA
Post-harvest losses due to pests	% loss reduction	Farmer reports, storage inspections	Bi-annual	MoA, ADP

These indicators provide insight into the PMP's technical efficacy, social acceptance, and environmental safety.

12.2 Reporting Standard monthly reports completed by technicians and ADP agents to the PMP dashboard

A structured reporting system ensures timely data capture, harmonization, and decision-making across all stakeholder tiers.

Standard Reporting Templates: Templates have been designed to include:

- Pest type and severity;
- Date and location (GPS-enabled);
- Control method applied;
- Success rate and farmer feedback

These templates are embedded in both paper-based and mobile platforms to enhance accessibility.

Institutional Roles in Reporting

Table 27 shows the institutional roles in the PMP implementation.

Table 27: Institutional Roles

Actor	Responsibility
ADP Extension Agents	Primary data collection and farmer engagement
Ministry of Agriculture	Validation and submission of state-wide reports
Ministry of Environment	Environmental residue and compliance reporting
SAPZ Steering Committee	Technical reviews and donor reporting summaries

Monthly and quarterly reports fed into a centralized PMP Monitoring Dashboard, allowing real-time visualization of pest patterns, chemical usage, and compliance levels.

12.3 Periodic Review Annual reviews with adjustments to thresholds, SOPs, and strategies, based on efficacy

Evaluation is more than measuring progress—it involves strategic reflection and course correction.

Annual PMP Review Workshops

Hosted by the SAPZ Steering Committee

The participants include Government ministries, ADP, farmer representatives, agro-processors, and NGOs.

Outputs: Revised action thresholds; Updated SOPs and pest profiles and Inclusion of new pest threats (e.g., invasive species).

Mid-Term and End-Term Evaluations

Conducted by an independent third-party evaluator (e.g., CRUTECH or a registered consultancy)

Evaluates: Cost-effectiveness of interventions; IPM knowledge retention among farmers and Institutional performance and budget utilization.

These evaluations ensure transparency, promote learning, and attract continuous funding from development partners such as AfDB and the World Bank.

Integration into ESMP

Monitoring data feeds directly into the Environmental and Social Management Plan (ESMP) framework for the CR-SAPZ to ensure cohesion with broader safeguards.

In summary, Monitoring and Evaluation Flow are:

- i. Farm Level – Pest data collected weekly by extension workers and FFS participants
- ii. LGA Level – Collated by ADP Zonal Coordinators
- iii. State Level – Reviewed by Ministries of Agriculture and Environment
- iv. CR-SAPZ Steering Committee – Monthly analysis and strategic decisions
- v. Donor Level – Annual narrative and financial reports to AfDB, World Bank

13 CONCLUSIONS

The Pest Management Plan (PMP) for the Adiabo Agro-Industrial Hub (AIH) provides a comprehensive framework to address pest-related challenges that threaten productivity, food safety, and environmental sustainability. The plan identifies key pest risks affecting major crops—such as cocoa mirids, rice stem borers, cassava mealybugs, yam beetles, maize stemborers, and storage pests like bruchids and weevils. Left unmanaged, these pests can cause yield losses of 15–40% and compromise both food security and market competitiveness.

To mitigate these risks, the PMP adopts Integrated Pest Management (IPM) strategies that prioritize preventive and ecological approaches. These include crop rotation, resistant varieties, habitat management, biological control, and safe post-harvest storage practices. Chemical pesticides are considered only as a last resort, with explicit bans on Highly Hazardous Pesticides (HHPs) and WHO Class Ia/Ib chemicals. NAFDAC-approved, low-toxicity formulations are used selectively under defined thresholds.

The PMP establishes clear institutional roles to ensure coordinated implementation. Farmers and cooperatives act as frontline adopters of IPM practices. ADP extension officers oversee training, surveillance, and digital reporting. The Ministry of Agriculture provides technical guidance and policy oversight, while the Ministry of Environment ensures compliance with residue monitoring and environmental safeguards. The SAPZ Steering Committee consolidates reporting and liaises with AfDB and development partners to maintain accountability.

Implementation is supported by a dedicated budget of ₦22.68 million (≈\$14,587.52), covering surveillance infrastructure, farmer training, IPM inputs, monitoring and evaluation, and public engagement. This results-based financing model ties expenditures directly to verifiable outputs. Monitoring commitments are embedded in the PMP through quarterly field inspections, residue testing, adoption surveys, and annual stakeholder review workshops. Indicators include pest incidence rates, pesticide use reduction, IPM adoption, farmer training coverage, and grievance resolution. Continuous feedback and adaptive management ensure the PMP remains effective and relevant.

In conclusion, the Adiabo AIH PMP ensures compliance with the African Development Bank's Integrated Safeguards System (ISS, 2023), particularly Operational Safeguard 3 on resource efficiency and pollution prevention. It also aligns with the World Bank's ESS3 and FAO IPM principles, demonstrating the project's commitment to sustainable, health-conscious, and environmentally sound pest management. This compliance assurance underscores that the AIH PMP not only mitigates pest risks but also advances the AfDB's broader objectives of climate-smart, inclusive, and sustainable agricultural transformation.

REFERENCES

- AfDB (2022). Environmental Safeguards for Agro-Industrial Projects. AfDB ESMP Guide
- AfDB (2022). Guidelines for Costing Environmental Safeguards in Agricultural Projects. AfDB Budgeting Guide
- AfDB (2022). Guidelines for Costing Environmental Safeguards in Agricultural Projects. AfDB Budgeting Guide
- FAO (2021). Community Participation in IPM Decision-making. FAO IPM Participation.
- FAO (2022). Integrated Pest Management Guidelines. FAO IPM Portal
- FAO (2023). Institutional Frameworks for Pest Management in Africa. FAO Link
- FAO (2023). Youth Engagement in Sustainable Agriculture. FAO Youth Strategy
- Food and Agriculture Organization (FAO) (2021). Building Farmer Capacity for IPM. FAO Training Guide
- Food and Agriculture Organization (FAO) (2022). *Integrated Pest Management (IPM) Guidelines. FAO IPM Guide*
- IFAD (2020). Toolkit on Gender-Responsive Extension and Pest Management. IFAD Gender Toolkit
- Stockholm Convention Secretariat (2023). POPs Regulation in Africa. POPs List.
- World Bank (2020). ICT and Agriculture Pest Surveillance Framework. World Bank ICT Tools
- World Bank (2020). Public Financial Management for Project Implementation Units. WB PFM Guide
- World Bank (2021). Costing Sustainable Pest Control Programs in SSA. WB Budgeting Framework
- World Bank (2021). Costing Sustainable Pest Control Programs in SSA. WB Budgeting Framework
- World Bank (2021). Environmental and Social Framework - ESS3: Resource Efficiency and Pollution Prevention. World Bank ESS3.
- World Bank (2021). Environmental and Social Monitoring Requirements – ESS1 & ESS10. WB Safeguards



World Bank (2021). ESS3 & ESS10 Environmental and Stakeholder Standards. WB Environmental Framework

World Bank (2022). ESS10: Stakeholder Engagement and Information Disclosure. WB ESS10 Guide

World Health Organization (WHO) & FAO (2022). International Code of Conduct on Pesticide Management: Guidelines on PPE. WHO-FAO PPE Guidelines

ANNEXES

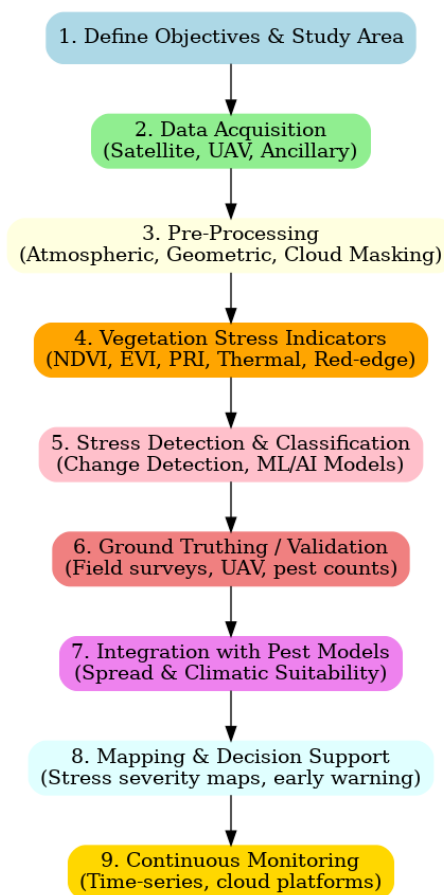
Annex A

Procedure for **Pest Detection Analysis Using GIS and Remote Sensing**

Satellite imagery and remote sensing have become powerful tools for early detection and monitoring of pest-induced stress in vegetation. The overall analysis of remote sensing technology for identifying pests and diseases in plants emphasizes significant advancements and methodologies that improve the monitoring and management of agriculture. This is made possible through multispectral and hyperspectral sensors which use indices such normalized difference vegetation index (NDVI), vegetation condition index (VCI), chlorophyll fluorescence, etc. to provide important information about the physiological condition of palm trees.

Methodology Flowchart

The flowchart (**Error! Reference source not found.**) illustrates the step-by-step methodology for using satellite imagery and remote sensing tools to track vegetative stress indicative of pest presence.



Methodology for Pest Detection Analysis

Techniques/Principles of Detection of Pest-Induced Plants

1) Vegetative Stress Signature: Plants under attack by pests (insects, pathogens, nematodes) exhibit reduced chlorophyll content, disrupted canopy structure, and altered water balance. These changes affect how plants absorb and reflect light.

(a) Spectral Changes (Visible bands - Red, Green, Blue): Pest stress often reduces “greenness” (chlorophyll absorption).

(b) Near-Infrared (NIR): Healthy vegetation reflects strongly, but stress reduces reflectance.

(c) Thermal Infrared: Infestation can cause increased canopy temperature due to reduced transpiration.

2) Remote Sensing Tools and Indices: Decrease in NDVI (Normalized Difference Vegetation Index) indicates loss of chlorophyll and vigour.

Normalized Difference Vegetation Index (NDVI) Mapping

NDVI (Normalized Difference Vegetation Index) is a widely used remote sensing index for monitoring vegetation condition. NDVI is a powerful, non-invasive tool for assessing plant health and detecting pest or disease-related stress by measuring changes in vegetation vigour and canopy reflectance patterns. Its role in detecting plant health and pest infestation include plant health monitoring, early stress detection, pest and disease impact, among others.

In plant health monitoring, NDVI measures the difference between near-infrared (which healthy plants strongly reflect) and red light (which plants absorb for photosynthesis). High NDVI values indicate vigorous, photosynthetically active vegetation, while lower values suggest stress, poor growth, or decline. In early stress detection, stress from water shortage, nutrient deficiency, or disease often reduces chlorophyll content and canopy density, lowering NDVI values. This allows detection of plant stress before visible symptoms appear. Pest infestations and pathogen infections damage leaves, reduce chlorophyll, and disrupt photosynthesis, leading to localized or widespread drops in NDVI. Comparing temporal NDVI data helps identify unusual declines linked to biotic stress.

Formula:

The NDVI calculation is a combined operation between the red spectral band (R) and near-Infrared spectral band (NIR) as follows:

$$NDVI = \frac{NIR - R}{NIR + R}$$

Bands 3 and 4, located in the red and near-infrared regions, respectively for TM and ETM + imageries; and bands 4 and 5 located in the red and near-infrared regions for OLI were utilised for NDVI calculation.

The Vegetation Condition Index (VCI)

The Vegetation Condition Index (VCI) is valuable in pest control analysis because it highlights abnormal vegetation stress relative to historical norms, enabling early detection, spatial targeting, and monitoring of pest-prone areas in GIS-based decision support systems.

The Vegetation Condition Index (VCI) is derived from the Normalized Difference Vegetation Index (NDVI), and it essentially compares current NDVI with its historical range (minimum and maximum) for the same location and time.

The **formula** is:

$$VCI = \frac{NDVI(current) - NDVI(min)}{NDVI(max) - NDVI(min)} \times 100$$

Where:

- NDVI_current = current NDVI value (e.g., from a satellite image for the current month/season).
- NDVI_min = long-term minimum NDVI value for that pixel and period (historical baseline).
- NDVI_max = long-term maximum NDVI value for that pixel and period.
- The result is scaled 0–100%, where:
 - 0% = extremely stressed vegetation (close to bare soil condition).
 - 100% = optimal or very healthy vegetation (historical maximum greenness).

Site Vulnerability to Pest infestation

GIS technology provides a powerful framework for assessing and mapping areas vulnerable to pest infestation. By integrating remote sensing indices (such as NDVI, EVI, and VCI) with other factors (such as soil type and land use), GIS can identify zones where crops are stressed, or conditions favour pest proliferation. Spatial analysis tools allow for hotspot mapping, overlay of pest occurrence records, and modelling of risk zones across landscapes. Temporal monitoring with satellite imagery helps track vegetation health changes, enabling early detection of pest outbreaks. This information supports precision agriculture by guiding targeted pest management, reducing pesticide use, and improving crop protection strategies. The vulnerability of each of the major crops to pest infestation is presented herein.

Identification of the conditions of crop health was done using remote sensing data to estimate the loss of leaf area which is related to the Normalized Difference Vegetation Index (NDVI). Thus, the

NDVI is mostly used as indication of plant vigor and is the ratio of (NIR-Red)/(NIR + Red). This index has been used more recently to monitor crop health (or stress) and subsequently used to predict yield on large scale agricultural fields such as cocoa, cassava, corn, wheat, rice and many more (Wang et al., 2016; Sultana et al., 2014; Zhang et al., 2012).

Pest Infestation Procedure

Suitability factors (vegetation status, slope, vegetation condition index, elevation, drainage) were selected and assigned weights to demonstrate the relative importance of each factor to the other factors in crop/grains production. The Analytic Hierarchy Process (AHP) as introduced by Saaty, (1980) was used to assign the weights to the participating factors in the cocoa pest vulnerability analysis. This method was adopted because it integrates a good technique which checks for consistency and reduce biasness in the decision-making process.

Additionally, vulnerability map was developed to show the areas vulnerable to pest infestation for cocoa production and display the spatial representation of these areas.

ANNEX B

A: Nigeria list of banned pesticides (Stockholm POPs)

Pesticide	Chemical Group	Reason for Ban
DDT	Organochlorine	Persistent Organic Pollutant (POP), bio-accumulative
Aldrin	Organochlorine	Highly toxic, environmental persistence
Dieldrin	Organochlorine	Carcinogenic, groundwater contamination
Lindane	Organochlorine	Toxic to humans and aquatic life
Chlordane	Organochlorine	Linked to liver damage and cancer

Sources: Stockholm POPs Chemical, NAFDAC Pesticide; NESREA

B; Approved vs Banned Pesticides (Aligned with WHO/FAO)

Category	Pesticide Type/Examples	Status in AIH PMP	Remarks
WHO Class Ia (Extremely Hazardous)	Aldicarb, Parathion	Banned	Not permitted under AIH PMP
WHO Class Ib (Highly Hazardous)	Carbofuran, Monocrotophos	Banned	Not permitted under AIH PMP
Persistent Organic Pollutants (POPs)	DDT, Lindane	Banned	Environmentally persistent, prohibited
WHO Class II (Moderately Hazardous)	Diazinon, Malathion	Restricted use (if approved by NAFDAC)	Only under controlled conditions
WHO Class III (Slightly Hazardous)	Neem-based formulations, Pyrethroids (low dose)	Approved	Allowed with proper PPE use

WHO Class U (Unlikely to present hazard)	Biopesticides, Bacillus thuringiensis (Bt)	Approved	Encouraged as safe alternatives
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Annex C

SOP for surveillance — sample from UC Davis logistics applied contextually

Step	Activity	Responsible Party
1	Identify crop and pest surveillance target	Extension Agent
2	Set trap or select scout method	Trained Farmer / Agent
3	Conduct field visit and count pest presence	Field Officer
4	Record data using digital or paper form	Enumerator
5	Report to PMP dashboard or ADP supervisor	Data Clerk

Note: SOP = Standard Operating Procedure

Sources: UC, IPM, SOP, FAO surveillance; World Bank Pest

Annex D

A: Training modules outline (IPM principles, SOPs, safety)

Module	Topic	Target Audience
Module 1	Introduction to IPM	Farmers, Extension Agents
Module 2	Safe Pesticide Use and PPE	All pesticide handlers
Module 3	Biological and Cultural Control Methods	Farmers
Module 4	Surveillance and Reporting	Enumerators, ADP Staff
Module 5	Gender and Youth in Pest Management	Community Focal Persons

Sources: FAO IPM WHO; IFAD

B: Reporting Template

Template Type	Key Fields	Responsible Institution
Pest Surveillance Form	Crop, pest observed, severity, control method applied, date	ADP Extension Officers
Pesticide Use Log	Product name, WHO classification, quantity applied, applicator name, PPE used	Farmers/Cooperatives
Training Attendance Sheet	Name, gender, group, training module completed, trainer name	ADP/Training Facilitators
GRM Form	Complaint description, date received, action taken, resolution status	SAPZ Steering Committee
M&E Template	Indicator, baseline, target, progress, corrective action, responsible institution	MoA, MoEnv, ADP

Annex E

Institutional contact directory

Institution	Contact Person	Email
Min. of Agriculture & Irrigation	Director, Plant Health	agri@crs.gov.ng
Min. of Environment	Pesticide Control Officer	env@crs.gov.ng
CRADP	IPM Coordinator	adp@crs.gov.ng
UNICROSS	Head, Crop Protection	crutech@edu.ng
SAPZ Steering Committee	Secretary	sapz@crs.gov.ng

Sources: CRADP, CRMENV, UNICROSS; CRMAI

Annex F

Relevant regulatory and international standards, including IPM definitions and framework

Framework	Issuing Body	Scope
IPM Guidelines	FAO	Best practices for integrated pest management
Pesticide Control Act	NAFDAC (Nigeria)	Regulation of pesticide use and safety
Stockholm Convention	UNEP	Global ban on Persistent Organic Pollutants (POPs)
National Environmental Regulations	NESREA	Control of agrochemical residue and safety
ESS 3 & ESS 10	World Bank	Resource efficiency, pollution, stakeholder engagement
AfDB OS 3	AfDB	Biodiversity, sustainable management of living natural resources, including pest management, conservation, and sustainable use to prevent adverse impacts.
AfDB OS 10	AfDB	Stakeholders' engagement, information disclosure, grievance mechanisms, ensuring effective participation

Note: ESS = Environmental Social Standards

Sources: World Bank ESS; FAO IPM; NAFDAC Agrochemical; UNEP Stockholm; NESREA

Annex G

Surveillance Template (Field Data Sheet)

Date	Location	Crop	Pest Type	Trap Type/Scout	Method	Pest Count	Action threshold Reached?	Intervention	Recommended Notes
YYYY-MM-DD	Village/Farm	Cassava	Green mite	Leaf inspection	X	per 10 leaves	Yes/No	Release predatory mites	Farmer alerted; follow-up scheduled
YYYY-MM-DD	Farm ID	Maize	Stem borer	Pheromone trap	Y	moths	Yes/No	Apply botanical pesticide	Ordered by extension services