

Rethinking Nigerian Chemical Pesticides Regulation: From Product Registration to Lifecycle Governance and National Information System

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Abstract: Chemical pesticides are synthetic chemical-based inputs for agricultural production, food security and public-health pest control. However, their benefits are accompanied by concerns relating to inappropriate use, illegal or unregistered products, pesticide residues in food, occupational exposure, environmental contamination, resistance development, obsolete pesticide stocks and inadequate disposal systems. Conventional chemical pesticide regulation has traditionally emphasized the authorization and registration of products before they enter the market. Product registration alone cannot ensure the safety of pesticides throughout their life span, from production to the end of its life. This review therefore proposes a transition from a predominantly product-centred regulatory model toward an integrated chemical pesticide lifecycle governance approach for Nigeria based on evidence from pesticide consumption, regulation, food residues, environmental exposure and international pesticide-management principles. Seven interconnected governance gaps are identified: pre-market risk-assessment gap; importation and trade-control gap; distribution and market-surveillance gap; pesticide-use and extension gap; food, occupational and environmental-exposure surveillance gap; post-registration and cumulative-risk gap; and obsolete-stock, phase-out and end-of-life management gap. These gaps demonstrate that regulatory effectiveness should not be measured solely by the number of products registered or banned but by the capacity of the regulatory system to follow pesticides from entry into the country through manufacture or importation, distribution, application, exposure, environmental fate, monitoring,

reassessment and eventual disposal. To achieve effectiveness, a Nigerian Chemical Pesticide Lifecycle Governance Framework (NCPLGF) and a Nigerian Chemical Pesticide Information System (NCPIS) are proposed. The framework integrates regulatory agencies, customs authorities, manufacturers, importers, distributors, farmers, extension services, laboratories, food-safety institutions, environmental agencies, researchers and communities through a traceable, data-driven governance cycle. Strengthening post-market surveillance, digital traceability, residue and environmental monitoring, resistance surveillance, licensing, obsolete-pesticide management and integrated pest management could provide a pathway toward safer and more sustainable chemical pesticide governance in Nigeria.

Keywords: Chemical pesticides; Nigeria; regulation; registration, lifecycle governance; research priorities

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1.0 Introduction

Chemical pesticides are important inputs in modern agricultural production and public-health pest management because they are used to prevent, control or eliminate organisms that damage crops, reduce food quality, transmit diseases or interfere with human activities. They include substances used against insects, weeds, fungi, rodents,

nematodes, mollusc and other organisms regarded as pests. In Nigeria, pesticides play an important role in crop protection and agricultural productivity and are increasingly used in response to crop losses, pest outbreaks and the need to improve food production. Recent evidence indicates that herbicides constitute a major component of pesticide use and importation in Nigeria, reflecting the country's continuing dependence on chemical pest-control products (Akinyemi et al., 2026). Chemical pesticides also have applications beyond agriculture, particularly in public-health programmes directed at disease vectors and other pests. However, the benefits of pesticide use must be balanced against potential risks to human health, food safety, biodiversity and environmental quality. The risks associated with pesticides may occur at virtually every stage of their lifecycle, including manufacture, formulation, importation, transportation, storage, distribution, application, environmental exposure and disposal. Farmers, pesticide applicators, distributors and other occupationally exposed groups may be particularly vulnerable where appropriate training, protective equipment, storage facilities and technical guidance are inadequate. Consumers may also be exposed through pesticide residues in food and drinking water, while pesticide contamination may affect soil, surface water, groundwater and non-target organisms. Vijver et al. (2017) emphasized the importance of post-registration monitoring because pesticide risks may continue after products have been authorized for use. Similarly, van den Berg et al. (2020) identified important gaps in pesticide lifecycle management across agriculture and public health, demonstrating that effective pesticide governance requires interventions beyond the initial authorization of pesticide products. The health implications of pesticide exposure constitute an important dimension of the pesticide-management debate. Pesticide

poisoning has been recognized as a major global public-health concern, particularly in agricultural communities where exposure may occur through occupational handling, inappropriate application, accidental contact or intentional ingestion (Hazafa et al., 2021; Roger, 2024). The risks associated with pesticide exposure are influenced by the toxicity of individual active ingredients, formulation, route and duration of exposure, application practices, availability of personal protective equipment and the effectiveness of regulatory controls. Consequently, pesticide regulation should not be based solely on whether a product has been authorized for use but should incorporate continuous assessment and management of exposure throughout its period of use.

Pesticide residues represent another important regulatory concern. Residues may remain in agricultural commodities following pesticide application and can create food-safety concerns where application rates, pre-harvest intervals or other conditions of use are not appropriately observed. Recent evidence from Nigeria has highlighted concerns regarding pesticide residues in cowpea production and their implications for human health and sustainable agricultural management (Okunlade et al., 2026). These concerns demonstrate the importance of linking pesticide authorization with food-residue monitoring, enforcement, farmer education and appropriate agricultural practices. Thus, pesticide governance requires not only control of which products may be placed on the market but also mechanisms for determining how, where, when and at what concentrations they are subsequently used.

Environmental contamination provides another justification for a lifecycle approach. Some pesticide active ingredients may persist in soil, sediments, water or biological systems, while others may affect non-target organisms or contribute to ecological disturbances. The environmental consequences of pesticide use may therefore continue after the immediate pest-control



function has been achieved. Post-registration environmental monitoring is consequently important for identifying risks that may not be adequately captured during per-market assessment (Vijver et al., 2017). In addition, the presence of obsolete or unwanted pesticides creates a further management challenge because expired, withdrawn or otherwise unusable products require controlled storage, collection, transportation and environmentally sound disposal. Effective pesticide governance must therefore address both active pesticide use and pesticide-related waste and legacy contamination.

The development and use of alternative technologies also form part of contemporary pesticide-management discussions. For example, nanobiopesticides have been investigated as emerging approaches to pest management, with potential applications in reducing dependence on conventional chemical pesticides and improving targeted pest control (Hazafa et al., 2021). However, emerging pesticide technologies also require appropriate assessment and regulatory oversight because new formulations and delivery systems may create novel exposure, environmental and regulatory considerations. The regulatory system must therefore remain sufficiently adaptable to accommodate technological developments while maintaining effective protection of human health and the environment.

Nigeria has established regulatory mechanisms intended to control the production, importation, distribution, sale and use of pesticides. The National Agency for Food and Drug Administration and Control (NAFDAC) provides a central product-registration framework through the *Pesticide Registration Regulations 2019* (NAFDAC, 2019). Product registration is intended to establish that pesticide products satisfy prescribed requirements relating to identity, quality, efficacy, labelling, packaging, safety and intended use before they are placed on the Nigerian market. Registration is therefore an essential

component of pesticide regulation because it provides a mechanism for determining which products may legally enter the market. However, registration should be regarded as the beginning of regulatory oversight rather than its endpoint.

Environmental regulation is also provided through the National Environmental Standards and Regulations Enforcement Agency (NESREA). The *National Environmental (Chemicals and Pesticides) Regulations 2023* provide a broader environmental framework for controlling chemicals and pesticides and protecting human health and the environment (NESREA, 2023). The existence of separate regulatory responsibilities for product authorization and environmental protection demonstrates the importance of inter-agency coordination. Effective pesticide governance requires these functions to be connected with agricultural extension, customs and border control, food-safety institutions, laboratories, public-health authorities and other organizations involved in pesticide management.

At the international level, pesticide management has progressively moved beyond a narrow emphasis on individual product authorization toward a broader lifecycle approach. The *International Code of Conduct on Pesticide Management* developed by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) emphasizes responsible pesticide management throughout the pesticide lifecycle and recognizes the shared responsibilities of governments, industry, pesticide users and other stakeholders (FAO & WHO, 2014). This approach recognizes that risks associated with pesticides may arise during production, importation, distribution, storage, use, monitoring and disposal and therefore require coordinated intervention at different stages of the lifecycle.

Subsequent FAO and WHO guidance has further elaborated the practical requirements of pesticide lifecycle management. Guidance for the inspection of pesticide producers,



importers, distributors and retailers emphasizes the importance of regulatory inspection and compliance monitoring across the pesticide supply chain (FAO & WHO, 2020a). Similarly, guidance on personal protection when handling and applying pesticides highlights the importance of reducing occupational exposure through appropriate protective measures, training and safe handling practices (FAO & WHO, 2020b). Guidance on pesticide licensing schemes further emphasizes the role of licensing and regulatory authorization in controlling pesticide-related activities beyond the initial registration of individual products (FAO & WHO, 2021a). The FAO and WHO compendium of pesticide-management guidance also brings together approaches covering pesticide regulation, risk reduction, appropriate use, protection of human health and environmental management (FAO & WHO, 2021b).

Monitoring and implementation are equally important components of effective pesticide governance. FAO and WHO (2023) emphasize the need to monitor the implementation and observance of the International Code of Conduct on Pesticide Management. Such monitoring requires information on regulatory implementation, pesticide management practices, institutional performance and emerging risks. A national pesticide-management system therefore requires reliable, accessible and interoperable information that can connect regulatory decisions with actual pesticide movement, use and environmental and health outcomes. International chemical-management instruments provide an additional dimension to pesticide regulation. The Rotterdam Convention establishes the Prior Informed Consent procedure for certain hazardous chemicals and pesticides in international trade, with Annex III providing a list of chemicals subject to the Convention's PIC procedure (Secretariat of the Rotterdam Convention [SRC], 2026). International restrictions and decisions regarding hazardous pesticides may therefore have

implications for national importation and regulatory controls. The Nigerian situation also requires consideration of pesticides that may be restricted or eliminated internationally but remain present in trade, storage or environmental matrices. The Sustainable Research and Action for Environmental Development (SRADeV Nigeria, 2024), for example, has documented concerns surrounding chlorpyrifos in Nigeria, illustrating the importance of considering the national status, international regulatory developments, environmental occurrence and actual use of individual pesticide active ingredients.

The persistence of pesticides and their environmental effects also demonstrate why regulatory status should not be viewed as a static classification. A pesticide may be registered at one point in time and subsequently become restricted, withdrawn, prohibited or subject to reassessment as new information concerning its health or environmental risks becomes available. Similarly, a pesticide that is no longer authorized for use may remain in storage or persist as a residue in environmental compartments. Consequently, regulatory oversight must be capable of responding to changes in scientific evidence, international regulatory decisions, resistance patterns, exposure data and environmental monitoring results.

Within Nigeria, therefore, product registration represents an important but incomplete component of pesticide governance. A pesticide that has successfully passed the registration process may subsequently be imported in substantial quantities, transported through multiple supply chains, stored under inappropriate conditions, distributed through formal or informal markets, applied incorrectly, used repeatedly on the same crop, contribute to pest resistance, leave residues in food, enter water and soil systems or eventually become obsolete. The regulatory challenge is consequently not simply whether a pesticide is registered or banned but whether the



regulatory system can identify, track, monitor and manage the pesticide throughout its entire lifecycle.

This concern is particularly important because pesticide regulation involves multiple institutions and information streams. Product-registration information may be held by one institution, importation records by customs authorities, distribution information by manufacturers and suppliers, pesticide-use information by agricultural agencies and extension services, residue data by food-safety and analytical laboratories, and environmental monitoring information by environmental agencies and research institutions. When these datasets are fragmented, regulators may have difficulty obtaining a complete picture of the quantity, location, use, exposure and environmental fate of particular pesticide products or active ingredients. The resulting information gap can weaken enforcement, risk assessment, post-registration review and timely regulatory intervention.

The literature has documented several components of the Nigerian pesticide problem. Studies and reports have examined pesticide consumption and regulation (Akinyemi et al., 2026), pesticide residues and associated health risks (Okunlade et al., 2026), environmental and occupational concerns (Hazafa et al., 2021; Vijver et al., 2017), pesticide poisoning (Roger, 2024), the management of hazardous pesticide active ingredients such as chlorpyrifos (SRADeV Nigeria, 2024), and international regulatory mechanisms governing hazardous chemicals and pesticides (SRC, 2026). In parallel, FAO and WHO have developed extensive guidance covering pesticide registration, inspection, licensing, personal protection, monitoring and broader lifecycle management (FAO & WHO, 2014, 2020a, 2020b, 2021a, 2021b, 2023). These contributions provide important foundations for understanding pesticide governance.

However, a significant knowledge and governance gap remains. Existing Nigerian studies have generally examined pesticide

consumption, residues, health effects, environmental contamination, regulatory status or specific pesticide-management problems as separate issues. Although these studies provide valuable evidence, there is limited integration of these different dimensions into a single national pesticide lifecycle governance architecture. In particular, insufficient attention has been given to how information generated during product registration, importation, customs control, distribution, agricultural use, food-residue monitoring, occupational-health surveillance, environmental monitoring, resistance surveillance, post-registration reassessment, pesticide phase-out and obsolete-pesticide disposal can be systematically connected to support continuous regulatory decision-making. The potential role of a dedicated national information system for linking these data streams and providing regulators with traceable, timely and decision-relevant pesticide information also remains insufficiently developed.

The central problem addressed in this review is therefore not the absence of pesticide regulation in Nigeria but the need to strengthen the continuity, integration, traceability and information base of pesticide governance across the entire lifecycle. Product registration remains necessary because it provides an important pre-market risk-control mechanism; however, it cannot by itself provide continuous oversight of pesticide movement, distribution, use, exposure, environmental fate, changing risk profiles and end-of-life management. Effective governance therefore requires a transition from a predominantly product-centred regulatory perspective toward an integrated lifecycle-management model.

Against this background, this review aims to critically examine the chemical pesticide regulatory landscape in Nigeria and propose a transition from predominantly product-centred regulation toward integrated chemical pesticide lifecycle governance supported by a national pesticide information



system. Specifically, the review seeks to: (i) examine the existing regulatory and institutional arrangements governing chemical pesticides in Nigeria; (ii) review evidence concerning pesticide consumption, health risks, food residues, environmental contamination and regulatory challenges; (iii) identify governance gaps across pesticide registration, importation, distribution, use, exposure monitoring, environmental surveillance, post-registration reassessment and end-of-life management; (iv) examine relevant international principles and practices for pesticide lifecycle management; and (v) propose a Nigerian Chemical Pesticide Lifecycle Governance Framework (NCPLGF) and a Nigerian Chemical Pesticide Information System (NCPIS) for improving regulatory coordination, traceability, monitoring and evidence-based decision-making.

The significance of the proposed approach lies in its potential to provide a more coordinated basis for managing chemical pesticides in Nigeria. The proposed framework could assist NAFDAC and other regulatory institutions in linking pre-market assessment with post-market surveillance, importation control, licensing, market inspection, residue monitoring, environmental surveillance, resistance monitoring and end-of-life management. It could also facilitate information exchange among customs authorities, manufacturers, importers, distributors, agricultural extension services, food-safety institutions, laboratories, environmental agencies, researchers and communities. By connecting regulatory information with evidence generated during actual pesticide use and environmental exposure, the proposed system could support earlier identification of emerging risks, more effective enforcement and better-informed decisions concerning registration, restriction, reassessment, phase-out and disposal.

The proposed lifecycle-governance approach is therefore intended to complement, rather than replace, existing Nigerian pesticide regulations. Its principal contribution is the

integration of regulatory activities and information flows that are frequently distributed across different institutions and stages of the pesticide lifecycle. Such integration would provide a basis for moving from a predominantly reactive approach to pesticide control toward a more continuous, preventive and evidence-based governance system consistent with the lifecycle-management principles advanced by FAO and WHO (FAO & WHO, 2014, 2020a, 2020b, 2021a, 2021b, 2023). In this context, the NCPLGF and NCPIS are proposed as conceptual mechanisms through which Nigeria could strengthen the traceability, accountability and effectiveness of chemical pesticide governance from market entry to final disposal.

2.0 Classification of Chemical Pesticide Regulatory Status

A major challenge in chemical pesticide governance is the need to distinguish between different regulatory, legal and management statuses. A pesticide may be legally registered in one jurisdiction but restricted or prohibited in another, while a product that is no longer authorized may remain in storage or persist as a residue in environmental compartments. Consequently, regulatory status should not be treated as a single, static classification. Rather, it should be understood as a set of related categories that describe the legal status, international status, market status and environmental or waste-management condition of a pesticide.

For the purpose of this review, the following regulatory and management categories are particularly relevant:

2.1 Internationally Restricted or Eliminated Pesticides

These are pesticides or other chemicals that are subject to international restrictions, phase-out or elimination under multilateral environmental agreements and related international regulatory mechanisms. The Rotterdam Convention establishes a Prior Informed Consent (PIC) procedure for certain hazardous chemicals and pesticides in international trade, while the Stockholm



Convention addresses persistent organic pollutants that meet specified criteria for persistence, bioaccumulation, long-range environmental transport and adverse effects. The Rotterdam Convention's Annex III provides the list of chemicals subject to the Convention's PIC procedure, including pesticides and severely hazardous pesticide formulations (Secretariat of the Rotterdam Convention [SRC], 2026). International regulatory developments are relevant to Nigeria because changes in the international status of an active ingredient can affect its importation, trade, national authorization and eventual phase-out.

2.2 Pesticides Prohibited or Restricted in Nigeria

This category comprises pesticide active ingredients or products whose manufacture, importation, sale, distribution or use is prohibited or restricted under applicable Nigerian regulatory instruments. The NAFDAC *Pesticide Registration Regulations 2019* identify pesticides that are not eligible for registration and provide regulatory mechanisms for controlling pesticide products in Nigeria (NAFDAC, 2019). The existence of a national prohibition or restriction does not necessarily mean that the substance has disappeared from the country because previously imported stocks, obsolete products, illegal products or environmental residues may remain.

2.3 Pesticides Restricted or Prohibited in Other Jurisdictions

A pesticide may be prohibited, restricted or undergoing phase-out in one country while remaining authorized under specified conditions in another. Differences between national regulatory decisions may arise from variations in risk assessments, agricultural practices, climatic conditions, exposure patterns, regulatory capacity and national legislation. Therefore, the regulatory status of a pesticide in another jurisdiction should not automatically be interpreted as evidence that the substance is prohibited in Nigeria. Instead, international regulatory developments should

serve as information for continuing risk assessment and national regulatory review.

2.4 Registered and Authorized Pesticides

Registered pesticides are products that have satisfied applicable regulatory requirements and have been authorized for specified purposes and conditions of use in Nigeria. Registration establishes a legal basis for market access and provides the regulator with an opportunity to impose conditions concerning formulation, labelling, packaging, application, target pests, crops, dosage and other requirements (NAFDAC, 2019). However, registration does not imply that a pesticide is risk-free or that its authorization cannot subsequently be reviewed. Registered pesticides therefore remain subject to appropriate monitoring, enforcement and, where necessary, reassessment.

2.5 Unregistered, Illegal or Counterfeit Pesticides

Unregistered pesticides are products that have not obtained the required regulatory authorization for manufacture, importation, sale, distribution or use. Counterfeit or adulterated pesticides represent a related but distinct concern because their composition, concentration, formulation or labelling may not correspond to the information declared by the legitimate manufacturer. Such products can undermine regulatory controls, create uncertainty regarding exposure and efficacy, and increase risks to users, consumers and the environment. NAFDAC's regulatory framework prohibits specified activities involving unregistered pesticide products, subject to prescribed exceptions and authorizations (NAFDAC, 2019).

2.6 Obsolete, Expired or Unwanted Pesticides

Obsolete pesticides are pesticide products that are no longer suitable for their intended use and may include expired, withdrawn, canceled, unwanted or otherwise unusable stocks. Such products may arise from changes in regulations, deterioration during storage, cancellation of registration, changes in agricultural practices or accumulation of unused stocks. Obsolete pesticides require



controlled identification, storage, collection, transportation and environmentally sound disposal because they can become sources of occupational and environmental exposure if improperly managed.

2.7 Legacy Pesticide Residues

Legacy pesticide residues refer to pesticide active ingredients or their transformation products that remain in environmental or biological compartments after their original application or use. They may occur in soil, sediments, surface water, groundwater, food webs or biological tissues depending on the chemical properties of the substance and environmental conditions. Legacy residues should be distinguished from obsolete pesticide stocks because the former refers primarily to contamination remaining in environmental or biological systems, whereas the latter refers to pesticide products that remain in storage or within the waste-management system. The distinction is important for environmental monitoring, remediation and risk assessment.

These categories are not necessarily mutually exclusive. A pesticide may, for example, be internationally restricted, prohibited under Nigerian regulations, present as an obsolete stock and simultaneously occur as a legacy environmental residue. Recognizing these overlapping statuses is important for developing a lifecycle governance system capable of following pesticides from regulatory authorization and market entry through use, monitoring, restriction, phase-out and eventual disposal or environmental remediation.

3.0 The Chemical Pesticide Regulatory Landscape of Nigeria

Nigeria has established a regulatory framework for controlling chemical pesticides through legislation, regulations, registration requirements and institutional responsibilities distributed across several government agencies and other stakeholders. NAFDAC's *Pesticide Registration Regulations 2019* provide a central regulatory framework for pesticide products manufactured, imported, exported, advertised,

sold, distributed or used in Nigeria (NAFDAC, 2019). The Regulations require pesticides to satisfy prescribed registration requirements and restrict specified activities involving products that have not received the required authorization, subject to defined exemptions and regulatory permissions.

The registration framework provides an important mechanism for controlling market entry. Applicants are required to provide prescribed information concerning the identity and composition of the product, intended uses, efficacy, safety and other regulatory requirements. The regulatory system also provides mechanisms for controlling labelling, packaging, advertising and other aspects of pesticide marketing and use. In addition, products included on applicable prohibited or restricted lists are subject to corresponding regulatory controls (NAFDAC, 2019).

Digital information systems have the potential to strengthen these controls. NAFDAC's publicly accessible product-information resources provide information that can assist users and regulators in identifying registered products, while product-verification mechanisms can support the authentication of registration information. Such tools provide important foundations for traceability. However, the existence of a product-registration database does not necessarily provide continuous information about the subsequent movement, quantity, distribution, use, exposure, environmental fate or disposal of a pesticide. Consequently, product registration and product verification should be regarded as important components of a broader information architecture rather than as complete lifecycle tracking systems.

Environmental regulation constitutes another important component of Nigeria's pesticide-governance structure. The *National Environmental (Chemicals and Pesticides) Regulations 2023* provide requirements directed at protecting human health and the environment from the harmful effects of hazardous chemicals and pesticides and supporting environmentally sustainable



management (National Environmental Standards and Regulations Enforcement Agency [NESREA], 2023). Environmental regulation is particularly important for addressing pesticide contamination, environmental exposure, waste management and risks to non-target organisms that may not be fully captured by product authorization alone.

Pesticide governance in Nigeria also involves a broad network of institutions and stakeholders. These include federal and state agricultural authorities, agricultural extension services, the Nigeria Customs Service, standards and quality-control institutions, research institutions and universities, manufacturers and importers, distributors and retailers, farmers and commercial agricultural enterprises, environmental and waste-management authorities, analytical laboratories, civil-society organizations and relevant international organizations and treaty mechanisms. Each actor may generate or hold information relevant to pesticide governance. The resulting institutional structure creates a fundamental governance question: who follows a pesticide after registration? In practice, responsibility is distributed across several institutions according to their respective mandates. NAFDAC may oversee product authorization and aspects of regulatory compliance; agricultural institutions and extension services are involved in pesticide use and farmer support; customs authorities are involved in border and import controls; environmental agencies address environmental risks and pollution; laboratories generate analytical evidence; and food-safety institutions may monitor residues. The central governance challenge is therefore not necessarily the absence of responsible institutions but the extent to which their functions and information systems are connected.

Fragmentation of regulatory information can create gaps between authorization and actual pesticide use. For example, information on a product's registration status may not

automatically provide information on the quantity imported, geographical distribution, frequency of application, crops treated, pesticide residues detected, environmental concentrations, resistance development or quantities requiring disposal. A lifecycle governance approach therefore requires mechanisms for connecting these information streams and converting them into evidence for continuous regulatory decision-making.

The Nigerian regulatory landscape should consequently be viewed as a network rather than as a single regulatory process. The effectiveness of this network depends on institutional coordination, information exchange, inspection, enforcement, laboratory capacity, monitoring and the ability to respond to changes in scientific evidence and pesticide risk. This provides the basis for examining the distinction between the conventional product registration model and a broader lifecycle governance approach.

4.0 Product Registration Model and Lifecycle Governance Concepts

4.1 Product Registration as the Conventional Regulatory Model

Product registration is primarily a pre-market regulatory mechanism through which an applicant provides prescribed information about a pesticide product and the competent authority determines whether the product satisfies applicable requirements for authorization. Depending on the regulatory system, submitted information may include the identity and composition of the product, formulation, intended uses, efficacy, toxicological information, environmental considerations, labelling, packaging and other safety-related information. In Nigeria, NAFDAC's *Pesticide Registration Regulations 2019* provide the principal regulatory basis for the registration and control of pesticide products (NAFDAC, 2019).

Product registration has several important regulatory functions. It establishes a legal threshold for market entry, prevents specified unregistered products from being legally marketed, provides a basis for controlling



product claims and labelling, and allows regulatory authorities to impose conditions concerning the use of authorized products. Registration can therefore reduce the likelihood that completely unassessed or inadequately characterized products will enter the formal market.

However, registration is fundamentally a decision based on the evidence available at the time of assessment and under specified conditions of use. Conditions may subsequently change. Pesticides may be applied at rates or frequencies different from those specified on the label; new toxicological or ecological evidence may emerge; patterns of pesticide consumption may change; pest populations may develop resistance; environmental monitoring may reveal previously unrecognized contamination; food-residue findings may identify concerns; and international regulatory decisions may alter the perceived risk of an active ingredient (FAO & WHO, 2014, 2020a, 2021a; Vijver et al., 2017).

Consequently, registration should be regarded as an essential entry point to pesticide governance rather than its endpoint. Effective regulation requires mechanisms capable of determining whether authorized products continue to be used according to approved conditions and whether new evidence warrants modification, restriction, suspension or cancellation of an authorization. This is the point at which product registration connects with post-registration monitoring and lifecycle governance.

4.2 Lifecycle Governance

Lifecycle governance considers a pesticide as part of a sequence of interconnected activities extending from research and development through manufacture or formulation, importation, registration, distribution, storage, application and exposure, monitoring, restriction or phase-out, obsolete-stock management and final disposal (Figure 1). This conceptualization is consistent with the lifecycle-management principles developed by FAO and WHO (2014, 2020a, 2020b, 2021a, 2021b, 2023)..



Fig. 1: Stages of Pesticide Lifecycle Governance

A simplified lifecycle can be represented as:
 Research and development →
 Manufacture/formulation → Importation →
 Registration/licensing → Distribution and
 storage → Sale and application → Human and
 environmental exposure → Food and
 environmental residues → Post-market
 monitoring → Reassessment/restriction →
 Phase-out → Obsolete-stock management →
 Disposal

The FAO/WHO *International Code of Conduct on Pesticide Management* provides the broader international basis for such an approach by emphasizing responsible pesticide management

throughout the lifecycle and shared responsibility among governments, industry, pesticide users and other stakeholders (FAO & WHO, 2014). Subsequent FAO/WHO guidance addresses specific components of this lifecycle, including inspection of producers, importers, distributors and retailers; personal protection during pesticide handling and application; licensing schemes; broader pesticide-management practices; and monitoring of implementation (FAO & WHO, 2020a, 2020b, 2021a, 2021b, 2023).

The conceptual distinction between the two approaches is therefore important. Product registration primarily determines whether a



particular pesticide product satisfies regulatory requirements for market authorization under specified conditions. Lifecycle governance goes further by asking whether the pesticide can be continuously identified, traced, monitored, controlled and reassessed from its entry into the country through its movement and use to its eventual removal from the market, disposal or persistence as an environmental residue.

In the Nigerian context, lifecycle governance would therefore connect product registration with import controls, distribution surveillance, agricultural extension, safe-use practices, food-residue monitoring, occupational exposure surveillance, environmental monitoring, resistance surveillance, post-registration reassessment, enforcement, phase-out and obsolete-pesticide management. The proposed approach does not replace product registration; rather, it places registration within a broader and continuous governance system.

This distinction provides the conceptual foundation for the proposed Nigerian Chemical Pesticide Lifecycle Governance Framework (NCPLGF) and Nigerian Chemical Pesticide Information System (NCPIS). The framework is intended to provide the governance structure, while the information system would provide the data infrastructure required to connect regulatory decisions, pesticide movement, use, monitoring, enforcement and end-of-life management.

5.2 Importation and Trade-Control Gap

A chemical pesticide may be legally registered in Nigeria but still enter the country through uncontrolled, inadequately monitored or unauthorized channels. Conversely, a pesticide that has been prohibited or restricted domestically may continue to enter through informal trade channels or may be represented by products containing similar active ingredients. This creates an important interface between pesticide regulation, border control and international trade.

Effective importation control therefore requires more than verifying whether a product appears on a registration list. It should also involve verification of the identity and regulatory status of the product, active ingredient, importer, quantity, batch and intended use at the point of entry. The system should be capable of detecting

discrepancies between authorized products and actual imports and should provide mechanisms for preventing the entry of prohibited, expired, counterfeit or otherwise unauthorized pesticide products.

Nigeria therefore requires stronger interoperability among NAFDAC, the Nigeria Customs Service, environmental regulatory authorities, agricultural authorities and relevant digital trade and port systems. Linking regulatory authorization with importation records would enable authorities to compare registered products and approved quantities with actual imports and provide an important foundation for national pesticide traceability.

5.3 Distribution and Market-Surveillance Gap

Registration does not automatically guarantee that the product encountered by farmers, commercial agricultural enterprises or other users is identical to the product assessed and authorized by regulators. Chemical pesticides may move through multiple distribution levels, including formal distributors, agricultural-input dealers, wholesalers, local markets and informal retail channels. Weak market surveillance can therefore permit the circulation of unregistered formulations, improperly labelled products, expired products, adulterated or counterfeit formulations, products containing incorrect concentrations of active ingredients, products marketed for unauthorized crops or uses, and products whose regulatory status has subsequently changed.

Effective market surveillance should therefore extend beyond periodic inspection of retail outlets. It should incorporate verification of registration status, product identity, batch information, expiration dates, labelling, formulation quality and authorized uses. Digital product identification, registration-number verification, batch-level traceability and periodic inspection of wholesalers, distributors and retailers could create a more transparent pesticide supply chain.

The proposed NCPIS could support this process by linking registered products to manufacturers, importers, batches, distributors and retail outlets. Such integration would make it easier to identify unauthorized products and facilitate targeted



recalls, regulatory enforcement and communication with pesticide users when the status of a product changes.

5.4 Chemical Pesticide-use and Extension Gap

Many pesticide-related risks become evident at the point of application. A registered pesticide can still generate unacceptable risks when it is applied incorrectly, used at inappropriate rates or frequencies, mixed improperly, applied to unauthorized crops, or used without adequate attention to pre-harvest intervals and environmental safeguards. Additional concerns include application near water bodies, inadequate personal protection, inappropriate disposal of pesticide containers and limited knowledge of resistance-management principles (van den Berg et al., 2020).

Evidence concerning pesticide residues in Nigerian agricultural commodities further demonstrates the importance of appropriate

pesticide-use practices. Okunlade et al. (2026), in a systematic review of studies published between 2018 and 2024, reported the detection of several pesticide groups in cowpea production and identified instances in which residue concentrations exceeded applicable regulatory limits.

Agricultural extension should therefore constitute a central component of pesticide governance. Farmers and other pesticide users require practical guidance on product selection, dosage, application frequency, mixing, personal protection, pre-harvest intervals, storage, container management, resistance management and environmentally responsible application. Integrated pest management should also be promoted as a strategy for reducing unnecessary reliance on chemical pesticides and combining appropriate pest-control techniques while minimizing risks to human health and the environment (FAO, 2017).

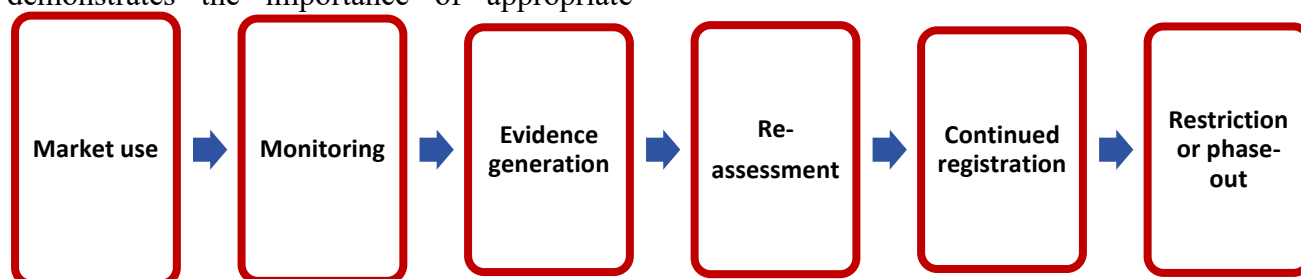


Fig. 2: Feedback loop for the Nigerian Chemical pesticide Regulatory System

5.7 Obsolete Stocks, Phase-Out and End-of-Life Gap

The final governance gap concerns the end of a chemical pesticide's useful or legal life. Pesticides may become obsolete because an active ingredient is banned or restricted, a product expires, a formulation is withdrawn, resistance reduces its efficacy, new toxicological or environmental evidence emerges, registration expires, or the product is replaced by a safer alternative. However, banning or withdrawing a pesticide does not automatically eliminate existing stocks. Consequently, a pesticide may move from the regulated market into an obsolete-stock and waste-management problem. The FAO/WHO lifecycle approach extends pesticide management beyond market use to include obsolete stocks, waste management and environmentally sound disposal (FAO & WHO, 2021).

Effective end-of-life governance therefore requires mechanisms for identifying, documenting, securing, collecting, transporting and appropriately disposing of obsolete, expired, withdrawn or otherwise unwanted pesticide products. These activities should be integrated into the national pesticide information system so that regulators can determine the location and status of obsolete stocks and verify their eventual removal from the supply chain.

6.0 The Proposed Nigerian Chemical Pesticide Lifecycle Governance Model

6.1 The Nigerian Chemical Pesticide Lifecycle Governance Framework

The proposed Nigerian Chemical Pesticide Lifecycle Governance Framework (NCPLGF) consists of 12 interconnected stages:

Stage 1: Research and development. Evaluation of efficacy, toxicity, environmental fate, resistance potential, effects on non-target



organisms, degradation products and available alternatives.

Stage 2: Manufacture and formulation. Control of formulation quality, active-ingredient concentration, contamination, manufacturing standards, worker protection and environmental safeguards.

Stage 3: Importation. Verification of importer authorization, product identity, active ingredients, quantity, registration status and country of origin.

Stage 4: Registration. Assessment of efficacy, human-health risks, environmental risks, food-residue considerations, intended uses, labelling and packaging.

Stage 5: Distribution and storage. Tracking of wholesalers, distributors, transportation, storage conditions and geographical movement of pesticide products.

Stage 6: Retail and market surveillance. Monitoring of registration status, product authenticity, formulation quality, expiration dates, labelling and unauthorized products.

Stage 7: Agricultural and public-health use. Monitoring of application practices, dosage, frequency, target pest, crop or public-health application, timing, personal-protection measures and environmental safeguards.

Stage 8: Exposure and residues. Monitoring of pesticide occurrence in food, water, soil, air and other relevant environmental media, together with occupational and indoor exposure where appropriate.

Stage 9: Post-registration surveillance. Evaluation of adverse effects, poisoning incidents, pesticide residues, resistance development, biodiversity effects and emerging scientific evidence.

Stage 10: Reassessment and regulatory decision-making. Regulatory decisions may include continuation of authorization, restricted use, modified labelling, additional controls, suspension or cancellation.

Stage 11: Phase-out and obsolete-stock management. Identification and controlled withdrawal of banned, restricted, obsolete, expired or cancelled pesticide products.

Stage 12: End-of-life management. Secure collection, storage, transportation, treatment and disposal of pesticide products, together with appropriate management of contaminated containers and related wastes.

The critical feature of the NCPLGF is that it should not operate as a purely linear sequence. Information generated during pesticide use, exposure assessment, food and environmental monitoring, post-registration surveillance and end-of-life management should feed back into future regulatory decisions, including registration, reassessment, restriction and phase-out (Fig. 3). The proposed framework therefore functions as a continuous regulatory cycle rather than a one-directional lifecycle chain.

6.2 Proposed NCPLGF Governance Architecture

The NCPLGF should be viewed as a multi-institutional governance network rather than a single-agency system. Different institutions have different statutory responsibilities across the pesticide lifecycle, and effective governance therefore depends on coordination, interoperability and information sharing. Table 1 presents a proposed governance architecture linking major lifecycle stages with principal governance actors and their key functions.

6.3. The Nigerian Chemical Pesticide Information System

One of the most important components of lifecycle governance should be a national pesticide information system. Nigeria already has digital regulatory infrastructure associated with pesticide registration. However, a lifecycle system needs to integrate information beyond registration. The proposed Nigerian Chemical Pesticide Information System (NCPIS) could contain; registered products, active ingredients, manufacturers, importers, import volumes, batch numbers, distribution records, retail surveillance, residue-monitoring results, poisoning/adverse-event reports, environmental-monitoring results, resistance reports, restricted products, banned products, obsolete stocks and disposal records. Such integration would enable regulators to identify discrepancies between registered quantity, imported quantity, distributed quantity, estimated use, detected residues and remaining stock and would substantially strengthen national chemical pesticide governance.

The governance architecture does not imply that every institution should perform every function. Rather, its central requirement is interoperability, coordination and information sharing. An inter-



agency pesticide-governance platform could therefore provide a mechanism through which NAFDAC, NESREA, the Nigeria Customs Service, agricultural authorities, food-safety

institutions, health institutions, research organizations and relevant industry stakeholders exchange appropriate pesticide information within their respective mandates.

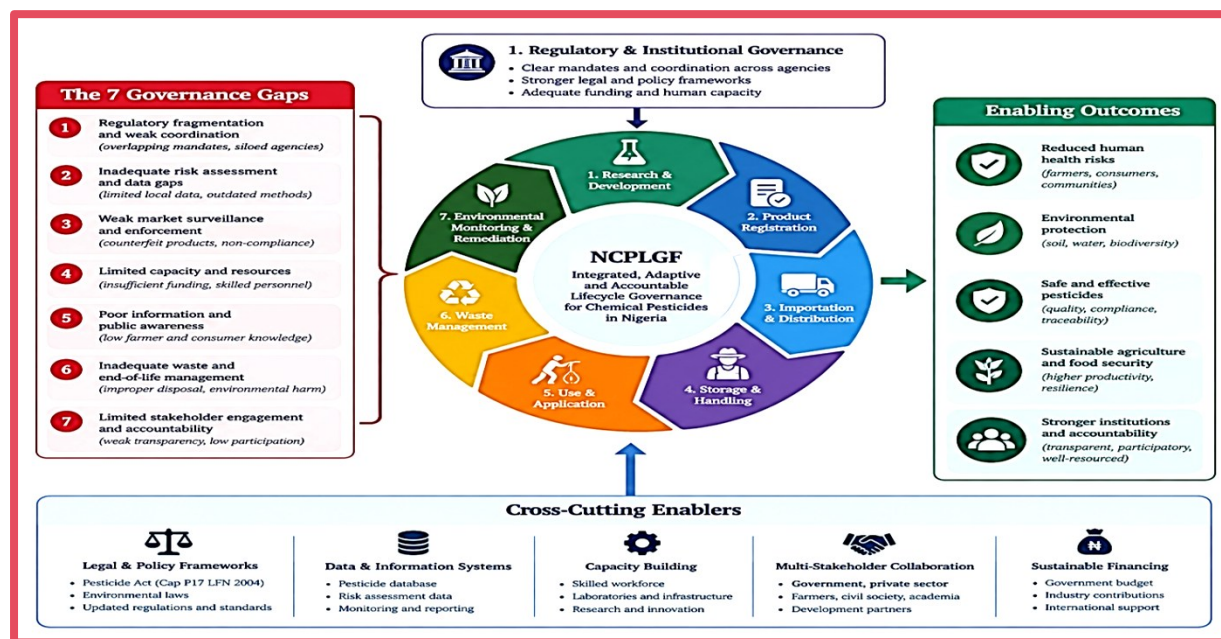


Figure 3. Proposed Nigerian Chemical Pesticide Lifecycle Governance Framework (NCPLGF). (Source: Authors' conceptualization based on FAO & WHO (2014, 2020a, 2020b, 2021a, 2021b, 2023), adapted to the Nigerian regulatory context).

Such a platform should also establish clear responsibilities for data generation, data validation, information sharing, regulatory reporting and response to identified risks. This would help prevent the fragmentation of information across institutional boundaries and strengthen the continuity of pesticide governance from market entry to end-of-life management.

6.3 The Nigerian Chemical Pesticide Information System

One of the most important components of lifecycle governance should be a national pesticide information system. Nigeria already has digital regulatory infrastructure associated with pesticide registration and product verification. However, a lifecycle information system would need to integrate information beyond registration and connect regulatory data with information generated during importation, distribution, use, exposure monitoring, enforcement and disposal. The proposed Nigerian Chemical Pesticide Information System (NCPIS) could contain information on registered products, active ingredients, manufacturers, importers, import

volumes, batch numbers, distribution records, retail-surveillance findings, residue-monitoring results, poisoning and adverse-event reports, environmental-monitoring results, resistance reports, restricted and banned products, obsolete stocks and disposal records. Such integration would enable regulators to identify discrepancies between registered quantities, imported quantities, distributed quantities, estimated use, detected residues and remaining stocks, thereby strengthening national pesticide traceability and regulatory oversight.

In addition, the NCPIS should incorporate digital traceability to connect the different stages of pesticide governance. The system could assign each registered pesticide a unique digital identity linked to the product name, active ingredient, manufacturer, importer, batch number, distribution channel, retailer and intended crop or use. A QR-based or equivalent digital verification system could potentially allow authorized users to confirm product identity and regulatory status and facilitate rapid communication or withdrawal when a product is



suspended, recalled, expired, adulterated, restricted or cancelled.

The proposed system could therefore transform pesticide governance from a predominantly document-based approach toward an integrated and traceable product-governance system.

Importantly, however, the NCPIS should not be understood simply as a database. It should function as an interoperable decision-support infrastructure that connects registration, trade, distribution, use, monitoring, enforcement and end-of-life management.

Table 1: Proposed NCPLGF Governance Architecture

Lifecycle stage	Principal governance actors	Key regulatory function
Research/development	Universities, research institutes, industry	Risk and efficacy evidence
Manufacture	Industry, NAFDAC, NESREA	Quality and environmental compliance
Importation	NAFDAC, Customs, environmental authorities	Ports, border and trade control
Registration	NAFDAC and relevant technical institutions	Pre-market authorization
Distribution & Retail	NAFDAC, states/local authorities	Licensing and traceability; Market surveillance
Use & exposure	Farmers, extension services	Responsible application
Food & environmental residues	Food-safety/laboratory institutions	MRL compliance
Post-market monitoring	NAFDAC, NESREA, research & institutions	Ecosystem surveillance; Risk reassessment
surveillance	NAFDAC, NESREA, health institutions	Risk reassessment
Restriction/Phase-out	NAFDAC, NESREA, industry	Controlled withdrawal
Obsolete-stock management	NAFDAC, NESREA, industry	Controlled withdrawal
Disposal	NESREA, waste authorities, industry	Safe end-of-life management

7.0 Lessons for Nigeria

The proposed framework is broadly consistent with the international pesticide-management architecture established by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO). The *International Code of Conduct on Pesticide Management* establishes responsible pesticide management as a shared responsibility involving governments, industry, pesticide users and other stakeholders and promotes management across the pesticide lifecycle (FAO & WHO, 2014). Subsequent FAO/WHO guidance addresses specific components of pesticide management, including inspection of producers, importers, distributors and retailers, personal protection during pesticide handling and application, pesticide licensing, broader

pesticide-management practices and monitoring of implementation (FAO & WHO, 2020a, 2020b, 2021a, 2021b, 2023).

These international principles provide a useful foundation for Nigeria. The country does not therefore need to construct lifecycle pesticide governance entirely from first principles. Rather, the principal challenge is to adapt established pesticide-management principles to Nigerian institutional, agricultural, economic and environmental realities.

An important lesson is that effective pesticide governance requires continuity across regulatory stages. Product registration should therefore be connected with import control, distribution surveillance, appropriate use, food and environmental monitoring, occupational exposure surveillance, post-registration reassessment, restriction, phase-out and end-of-



life management. A second lesson is the importance of reliable information. Without information on which products are authorized, what quantities enter the country, where products are distributed, how they are used, what residues are detected, what adverse events occur and what obsolete stocks remain, regulatory authorities may have difficulty undertaking timely evidence-based risk management.

A third lesson concerns shared institutional responsibility. Government agencies cannot independently manage every stage of the pesticide lifecycle. Manufacturers, importers, distributors, farmers, extension personnel, laboratories, health institutions, researchers and communities all contribute to pesticide governance. The proposed NCPLGF and NCPIS should therefore function as mechanisms for coordinating responsibilities and information rather than concentrating all pesticide-management functions within a single institution. For Nigeria, the principal requirement is therefore not simply the introduction of additional regulations but the integration, implementation and continuous evaluation of existing regulatory functions through coordinated surveillance, interoperable information systems, clear institutional responsibilities and evidence-based risk reassessment.

8.0 Research Priorities for A Workable NCPLGF

Implementation of lifecycle chemical pesticide governance requires a stronger national evidence base supported by an integrated pesticide information system. Nigeria should therefore recognize pesticide regulation as a continuum extending from research, production and importation through registration, distribution, use, monitoring, reassessment, phase-out and disposal. Higher-education institutions, research institutes, regulatory agencies and industry should support research that generates reliable evidence for pesticide risk assessment, monitoring and regulatory decision-making. Priority areas should include the development of a national pesticide-use inventory to establish patterns of pesticide consumption across crops, geographical regions and sectors; national pesticide-residue surveillance to determine pesticide residues in

food and agricultural commodities; environmental-fate studies to characterize the occurrence, persistence, transport and transformation of pesticides under Nigerian environmental conditions; and resistance surveillance to identify changes in pest susceptibility and support integrated pest-management strategies.

Additional research priorities should include obsolete-stock mapping to determine the location, quantity and condition of expired, withdrawn or unwanted pesticide products; evaluation of alternative pest-management technologies; assessment of lower-risk pesticides and biopesticides; and investigation of strategies for reducing unnecessary dependence on hazardous chemical pesticides.

Research should also examine occupational pesticide exposure, pesticide poisoning and adverse events, effects on non-target organisms, environmental contamination, pesticide residues and the effectiveness of existing regulatory and enforcement mechanisms. Particular attention should be given to generating data that can be incorporated into the proposed NCPIS.

Finally, research institutions should contribute to the development of standardized pesticide datasets, analytical methods, risk indicators and decision-support tools capable of supporting registration, post-registration reassessment, restriction, phase-out and end-of-life management. A continuously updated national evidence base would allow pesticide regulation to become more responsive to emerging scientific evidence and changing patterns of pesticide use and exposure

9.0 Conclusion

Nigeria's chemical pesticide regulatory challenge should no longer be framed exclusively as a problem of registering, restricting or banning individual products. Product registration remains essential, but it represents only one stage of pesticide governance. The evidence indicates that pesticide risks can emerge or become amplified after registration through uncontrolled importation, distribution, inappropriate use, food residues, environmental contamination, resistance, inadequate post-market monitoring and poor management of obsolete stocks. Recent Nigerian reviews have documented continuing



regulatory and environmental challenges, including pesticide residues and weaknesses in enforcement and data systems (Akinyemi *et al.*, 2026; Okunlade *et al.*, 2026). This review identifies seven interconnected governance gaps: and addressing these gaps requires a transition from product-centred regulation to lifecycle governance. The proposed Nigerian Chemical Pesticide Lifecycle Governance Framework (NCPLGF) provides a conceptual pathway for achieving this transition. It connects registration with importation, distribution, use, exposure monitoring, post-registration surveillance, reassessment, phase-out and disposal while establishing feedback between real-world evidence and regulatory decision-making. Such an approach would move pesticide regulation from a predominantly reactive system toward a preventive, evidence-based, adaptive and sustainable governance model capable of protecting agricultural productivity while simultaneously strengthening food safety, environmental protection and public health.

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Compliance with Ethical Standards

Declaration

Ethical Approval

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