CLIMATE SMART AGRIBUSINESS FINANCING (CSAF) FORESTRY AND WASTE MANAGEMENT

GLOBAL ISSUES & LOCAL PERSPECTIVES

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Part two: FORESTRY AND WASTE MANAGEMENT

Preface

This book adopts an exegetical approach as well as a pedagogic model, making it attractive agriculture and environmental economics teachers, professional practitioners and scholars. It is eschews pedantry and lays bars the issues in such clarity that conduces to learning. The book elaborates on contemporaneous **Climate Smart Agribusiness Financing (CSAF) Forestry and Waste Management** issues of global significance and at the same time, is mindful of local or national perspectives making it appealing both to international and national interests. The book explores the ways in which **Climate Smart Agribusiness Financing (CSAF) Forestry and Waste Management** issues are and should be presented to increase the public's stock of knowledge, increase awareness about burning issues and empower the scholars and public to engage in the participatory dialogue **Climate Smart Agribusiness Financing (CSAF) Forestry and Waste Management** necessary in policy making process that will stimulate increase in food production and environmental sustainability. **Climate Smart Agribusiness Financing (CSAF) Forestry and Waste Management :** *Global Issues & Local Perspectives* is organized in two parts. Part One deals with The Concept of **Climate Smart Agribusiness Financing (CSAF)**, Part Two is concerned with The Concept of **Forestry and Waste Management**

Eteyen Nyong; August 2026

Chapter 13

Microplastic Contamination in Niger Delta Fish Species: Bioaccumulation, Food Safety Risks, and Implications for Sustainable Fisheries Financing in Nigeria.

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1.0 Introduction

The Niger Delta covers roughly 70,000 square kilometres across Bayelsa, Delta, and Rivers States in Southern Nigeria. It is one of the largest and most biodiverse wetland systems on the African continent, home to an estimated 40 million people and hundreds of thousands of artisanal fishers whose livelihoods depend directly on the region's water bodies (Keme-Iderikumo *et al.*, 2024). Fish from the area's creeks, rivers, estuaries, and coastal waters supply a substantial share of the animal protein consumed across Southern Nigeria, with products moving through both domestic and export markets. Yet the Niger Delta has been exposed to environmental pollution on a scale that few regions have endured. Decades of oil exploration and production have left behind chronic hydrocarbon contamination, repeated spill events, and widespread gas flaring, each of which has altered water quality, sediment chemistry, temperature regimes, and fish population dynamics (Keme-Iderikumo *et al.*, 2024; Omokpariola *et al.*, 2025). A UNEP (2011) assessment of Ogoniland in 2011 found benzene in groundwater at concentrations more than 900 times above World Health Organization safety limits. A 2023 Bayelsa State-commissioned report described the region's pollution as an environmental crisis, linking oil spills to an estimated 16,000 neonatal deaths per year and a life expectancy of only 41 years in the Delta, compared with 61 years nationally (Ekpo, 2023).

Microplastics are plastic particles measuring between 1 micrometre and 5 millimetres. They are now detected in marine, freshwater, estuarine, and terrestrial ecosystems across the globe (Fred-Ahmadu *et al.*, 2024). Their proliferation in aquatic environments is driven by the rise in global plastic production, from over 1.5 million metric tonnes in the 1950s to approximately 350 million metric tonnes in 2017, and the persistent failure to manage plastic waste effectively (Fred-Ahmadu *et al.*, 2024). In the Niger Delta, these global trends interact with local conditions: inadequate solid waste management, dense riverine plastic litter, petroleum-related plastic debris, and the degradation of synthetic fishing gear. Together these factors make the region particularly susceptible to microplastic accumulation.

The scientific literature on microplastic contamination in Niger Delta fish remains comparatively sparse relative to other regions. There is, however, a growing body of Nigerian research examining microplastics in rivers, lagoons, coastal waters, and fish tissue, with findings that document significant contamination across multiple species and ecosystem types (Doherty *et al.*, 2024; Ugosor *et al.*, 2025). These findings carry implications that extend well beyond ecology: they bear on the safety of seafood consumed by millions of Nigerians and on the economic viability of the fisheries sector as a recipient of development finance.

This chapter examines three interconnected dimensions of the microplastic problem in the Niger Delta. First, it traces the sources and pathways through which microplastics enter Niger Delta water bodies and the mechanisms by which commercially important fish species accumulate them across tissue types and trophic levels. Second, it analyses the toxicological and food safety risks posed by contaminated fish, drawing on global ecotoxicological evidence and situating it within Nigeria's dietary patterns and regulatory environment. Third, it examines the implications of microplastic contamination for fisheries financing in Nigeria, arguing that unaddressed contamination risk constitutes a material structural impediment to investment in the sector. The chapter closes with an integrated set of policy and research recommendations.

2.0 Microplastics: Definition, Classification, and the Global Context of Aquatic Pollution

2.1 Classification and Origins of Microplastics

Plastic debris in aquatic environments is classified by size: megaplastics exceed 100 mm, macroplastics range from 25 to 100 mm, mesoplastics occupy 5 to 25 mm, microplastics span 1 micrometre to 5 mm, and nanoplastics are sub-1 micrometre (Fred-Ahmadu *et al.*, 2024). Within the microplastic category, a further distinction separates primary from secondary origins. Primary microplastics are manufactured at sub-5 mm scale or shed directly from products during use. Secondary microplastics arise from the physical, chemical, and biological breakdown of larger plastic items under environmental conditions, including UV radiation, mechanical abrasion, wave action, and heat (Fred-Ahmadu *et al.*, 2024).

Common primary sources include plastic pellets (nurdles), paint particles, wastewater effluents and sewage sludge, synthetic textile fibres released during laundering, rubber tyre wear particles, and microbeads from personal care products (Fred-Ahmadu *et al.*, 2024). Secondary sources include municipal plastic waste such as bags, bottles, and packaging; discarded fishing gear; agricultural plastic films; and the gradual breakdown of larger plastic debris. In the Niger Delta, all of these pathways operate simultaneously, and several are intensified by the region's petrochemical activities, which generate plastic waste streams not typical of other coastal environments.

2.2 Global Prevalence in Aquatic Ecosystems and Fish

Aquatic environments, from freshwater rivers to open oceans, function as the primary sink for circulating microplastics. Microplastics have been detected in virtually every ecosystem sampled, from remote Arctic seas to highland Himalayan rivers, and across fish species on every inhabited continent (Doherty *et al.*, 2024). More than 660 marine species have been documented as contaminated by plastics of various sizes; fish specifically acquire microplastics through accidental ingestion, trophic transfer from contaminated prey, and direct contact with particle-laden water and sediment (Oza *et al.*, 2024).

The gastrointestinal tract and gills are the primary sites of microplastic accumulation in fish, but particles have been detected in liver, muscle, gonads, and other organs. This distribution has direct food safety implications given that several of these tissues are commonly consumed by humans (Ghosh, 2024). Contamination levels vary by feeding guild: carnivorous and omnivorous species tend to carry higher microplastic loads than strict herbivores, and bottom-dwelling demersal species are generally more contaminated than pelagic ones because microplastic concentrations are elevated in sediments (Doherty *et al.*, 2024). Globally, an estimated 14 million tonnes of plastic enter the oceans each year, sustaining the environmental pool from which biological uptake continues (ScienceDirect, 2025).

2.3 Microplastics as Vectors for Co-contaminants

An important dimension of microplastic pollution is the tendency of plastic particles to adsorb and transport other chemical contaminants. Persistent organic pollutants (POPs), including polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), DDT and its metabolites, and organochlorine pesticides, partition onto plastic surfaces because both the polymer matrix and the pollutants share hydrophobic properties (Omokpariola *et al.*, 2025). Heavy metals, including lead, cadmium, copper, zinc, and mercury, similarly adsorb to microplastic surfaces in polluted water bodies, sometimes at concentrations many times higher than those measured in the surrounding water column (Chris & Anyanwu, 2023).

In the Niger Delta, this co-contaminant pathway is particularly significant. The region's water bodies already carry elevated PAH loads from petroleum spills and gas flaring combustion products, heavy metals from industrial effluents and small-scale mining, and organochlorine pesticides from agricultural runoff (Omokpariola *et al.*, 2025). Microplastics entering these already-contaminated systems acquire a toxic surface layer and can then deliver this mixture of pollutants directly into fish digestive tissue upon ingestion. The result is a toxicological hazard considerably larger than the particle alone would generate (Fred-Ahmadu *et al.*, 2024).

3.0 The Niger Delta as a High-Risk Microplastic Accumulation Zone

3.1 Environmental Stressors and Baseline Contamination

Any assessment of microplastic contamination in the Niger Delta must be read against the region's pre-existing environmental degradation. Petroleum extraction has introduced chronic hydrocarbon contamination across soils, sediments, surface water, and groundwater (Ekpo, 2023; Keme-Iderikumo *et al.*, 2024). Nigeria is among the world's top gas-flaring nations, burning approximately 16% of associated gas annually (Keme-Iderikumo *et al.*, 2024). Flaring releases nitrogen oxides, sulfur dioxide, methane, carbon dioxide, and carcinogenic volatile organic compounds including benzene, toluene, and xylene into the regional atmosphere, where they deposit onto water bodies and add to the chemical load already present in aquatic sediments.

Research on the Isaka-Bundu tidal mangrove swamp in Rivers State found potential ecological risk indices (PERI) for toxic metals in sediment and water exceeding 600, placing the system in the very high ecological risk category (Chris & Anyanwu, 2023). Cadmium, copper, zinc, lead, and arsenic were detected above both World Health Organization and European Commission guidelines, and pollution load indices (PLI) exceeded 1.0 at every sampling station, indicating extremely toxic conditions (Chris &Anyanwu, 2023). These baseline conditions mean that any microplastic entering the system is likely to adsorb significant co-contaminant loads before a fish ingests it.

3.2 Sources of Microplastics Specific to the Niger Delta

The Niger Delta's microplastic burden derives from several overlapping source categories. Inadequate solid waste management across the region's urban centres, including Port Harcourt, Warri, Asaba, and Yenagoa, allows plastic packaging, beverage containers, and single-use plastics to reach waterways through surface runoff, open dumping, and flooding (Ugosor *et al.*, 2025). The region's dense network of creeks and rivers carries plastic debris downstream toward estuarine deposition zones, and seasonal flood events play a particularly large role in mobilising previously deposited material (Fred-Ahmadu *et al.*, 2024).

Artisanal fisheries are themselves a significant local source. Synthetic nylon nets, plastic floats, monofilament lines, and plastic-coated ropes are ubiquitous along Niger Delta waterways and degrade over time into secondary microplastic fibres and fragments (Keme-Iderikumo *et al.*, 2024). Keme-Iderikumo *et al.* (2024), in their study of Taylor Creek, Bayelsa State, noted that fishing implements in the area undergo accelerated degradation partly attributable to the chemically hostile conditions created by gas flaring pollution, which accelerates photodegradation and oxidative breakdown of synthetic polymers.

Petroleum industry activities add a further distinct input. Exploration and production operations generate plastic pipe insulation, synthetic seals, polymer-coated drilling components, and plastic sheeting. Illegal crude oil refining operations and pipeline vandalism events release hydrocarbon-contaminated plastic debris directly into surrounding waterways. Atmospheric deposition of microplastic fibres from gas flaring combustion products and vehicle tyre wear particles provides an additional diffuse pathway.

3.3 Documented Evidence of Microplastic Contamination in Nigerian Waters

The empirical evidence for microplastic contamination in Nigerian aquatic systems has grown substantially since 2020. Doherty *et al.* (2024), in a study assessing fish, sediment, and water across the six geopolitical zones of Nigeria, confirmed microplastic occurrence across diverse inland river environments. Carnivorous species including *Hepsetus odoe*, *Chrysichthys nigrodigitatus*, and *Lates maximus* showed higher contamination than herbivorous species such as *Oreochromis niloticus*, consistent with trophic transfer dynamics reported elsewhere. Microplastics were found in stomach contents, gills, and sediment samples across all study regions, establishing contamination as a nationwide phenomenon in Nigerian freshwater ecosystems.

Isaac (2024) specifically assessed microplastic concentrations along the Otuoke River in the Niger Delta, confirming their presence in this sensitive ecosystem. A 2025 review by Ugosor *et al.* compiled field studies from across the country, documenting that research by Isaac *et al.* (2023), Akinhanmi *et al.* (2023), Aliyu *et al.* (2023), and Nduka *et al.* (2024) collectively confirmed microplastic prevalence across Nigerian freshwater, estuarine, and coastal environments. PVC, polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET) were the most frequently identified polymer types, all common in single-use consumer packaging and fishing gear (Ugosor *et al.*, 2025).

4.0 Bioaccumulation of Microplastics in Niger Delta Fish Species

4.1 Pathways of Microplastic Uptake in Fish

Fish acquire microplastics through three pathways. The most important is direct ingestion: fish mistake microplastics for food items because of their size, colour, and buoyancy, or consume them incidentally while feeding on zooplankton, invertebrates, or other small organisms (Oza *et al.*, 2024). Trophic transfer is the second pathway: predatory fish that consume prey species already carrying microplastics in their tissues can accumulate additional particle loads, a process capable of producing biomagnification across trophic levels (Bhatt and Chauhan, 2023). The third pathway is physical contact, in which microplastics adsorb to gill surfaces and enter the circulatory system through respiratory uptake, or adhere to the external body surface (Fred-Ahmadu *et al.*, 2024; Ghosh, 2024).

Once ingested, microplastics move through the oesophagus into the stomach and intestines. Some particles are trapped in mucus and excreted, but smaller fragments can translocate across the gut epithelium into the bloodstream and distribute to organs including the liver, spleen, kidney, gills, muscle, and gonads (Ghosh, 2024). The extent of translocation and tissue distribution depends on particle size, shape, polymer type, surface charge, and individual fish physiology, including gut pH, transit time, and the nature of any biofilm on the particle surface (Oza *et al.*, 2024).

4.2 Commercially Important Species and Organ-Level Distribution

The Niger Delta supports a diverse range of commercially exploited fish species. Artisanal catches in the Taylor Creek study area recorded species from the genera *Clarias* (catfish), *Chrysichthys* (bagrid catfish), *Heterotis* (African arowana), *Oreochromis* and *Tilapia* (tilapia), *Gymnarchus* (African knifefish), *Lates* (Nile perch), and *Hepsetus* (African pike), spanning a wide range of feeding guilds and occupying both pelagic and benthic habitats (Keme-Iderikumo *et al.*, 2024).

Global evidence from comparable species indicates that microplastic accumulation varies by feeding guild and habitat type. Ghosh (2024) confirmed across bioaccumulation studies that microplastics most frequently concentrate in the gut and gills before distributing through the circulatory system to other tissues. Doherty *et al.* (2024) found microplastics in the stomachs of carnivorous Nigerian species but not in herbivorous *Oreochromis niloticus*, indicating that trophic position influences exposure. For broadly omnivorous species such as *Clarias gariepinus*, which is widely consumed across the Niger Delta, both direct environmental ingestion and trophic transfer from contaminated invertebrate prey are likely to contribute to tissue burden.

The tissue distribution of microplastics carries direct food safety significance. When microplastics are confined to the gastrointestinal tract, a consumer who removes the gut during preparation substantially reduces exposure. When microplastics are found in muscle tissue, liver, and gills, all of which are commonly consumed, preparation practices offer no protection (Oza *et al.*, 2024; Ghosh, 2024). In the Niger Delta context, where small whole fish are frequently eaten including organs, per-meal microplastic exposure may be considerably higher than estimates derived from studies that analysed only filleted muscle.

4.3 Trophic Transfer and Biomagnification in the Niger Delta Food Web

The Niger Delta food web runs from phytoplankton and periphyton through zooplankton and benthic invertebrates to small fish that are preyed upon by larger carnivorous species. Microplastics entering this web at its base can move upward through predation. Whether microplastics biomagnify, increasing in concentration with each trophic step, or are partly excreted such that concentrations plateau, remains debated in the literature. What is established is that trophic transfer of microplastics and their associated chemical cargo does occur (Bhatt & Chauhan, 2023; Fred-Ahmadu *et al.*, 2024).

In the Niger Delta, the co-contaminant dimension of this transfer is amplified by elevated PAH concentrations from petroleum activities. Omokpariola *et al.* (2025), reviewing the role of POPs in cancer development in Nigeria, documented that PAHs and volatile organic compounds emitted during oil flaring and petroleum processing are associated with elevated cancer risk, particularly for lung, skin, and liver cancer. If microplastics in the Niger Delta food web are carrying adsorbed PAH loads from petroleum contamination, their consumption by fish and, subsequently, by humans may represent a dietary PAH exposure route not captured in current food safety monitoring.

4.4 Interaction with Toxic Metals in Niger Delta Sediments

The sediment-water interface in Niger Delta water bodies functions simultaneously as a settling zone for microplastics and as a site of intensive microplastic-metal interaction. Chris & Anyanwu (2023) showed that cadmium, copper, zinc, lead, and arsenic are present in Niger Delta mangrove sediments at concentrations well above international ecological risk thresholds. Benthic-feeding species such as *Chrysichthys nigrodigitatus* and various catfish that forage in and around contaminated sediments face simultaneous exposure to sediment-associated microplastics and to dissolved and sediment-bound metals. Where microplastics concentrate metals on their surfaces, ingestion of sediment-associated particles may deliver a heavy metal dose exceeding what water-phase concentrations alone would predict (Chris & Anyanwu, 2023).

The potential for cadmium, lead, and arsenic, all identified by Chris & Anyanwu (2023) as major risk contributors in Niger Delta mangrove sediments, to be co-delivered through microplastic ingestion compounds the ecological and public health risk substantially. Ekpo (2023) documented that heavy metal poisoning produces neurological damage, kidney failure, and reproductive toxicity, effects that worsen with chronic exposure through contaminated fish consumption.

5.0 Toxicological Effects on Fish and Ecological Consequences

5.1 Physiological Effects on Fish

Ingestion and tissue accumulation of microplastics produce a documented range of physiological impairments. Ghosh (2024) confirmed across bioaccumulation studies that microplastic exposure affects haematological indices connected to immunity, osmotic pressure, blood clotting, molecular transport, and fat metabolism. At the cellular level, microplastics induce oxidative stress through the generation of reactive oxygen species (ROS) that overwhelm antioxidant defence systems, leading to lipid peroxidation, protein denaturation, and DNA strand breaks, the last of which is particularly concerning given its mutagenic and carcinogenic potential (Ghosh, 2024). Neurotoxicity is another documented consequence. Microplastic exposure produces behavioural abnormalities including altered predator avoidance, disrupted schooling, and impaired feeding efficiency, each of which reduces individual fitness and has population-level implications for Niger Delta fish stocks (Ghosh, 2024). Reproductive dysfunction has been reported in fish exposed to microplastics both alone and in combination with adsorbed endocrine-disrupting chemicals: reduced gonadal development, disrupted spawning, decreased egg viability, and altered sex hormone profiles are all documented outcomes (Zurub *et al.*, 2024). Growth retardation has been consistently reported as well, with implications for the commercial value of affected fish (Ghosh, 2024).

Histological examination of microplastic-exposed fish shows tissue damage in the liver, kidney, intestinal mucosa, and gill lamellae. Gill damage is especially relevant because the gills are the organ most directly in contact with the water column and the site of primary respiratory function (Fred-Ahmadu *et al.*, 2024). Niger Delta fish populations are already under physiological stress from hypoxia associated with high BOD from organic pollution, thermal stress from gas flaring-induced water temperature elevation, and chronic hydrocarbon exposure. The addition of microplastic-related burden to this context is expected to produce multiplicative rather than merely additive physiological stress.

5.2 Ecological Implications for Niger Delta Fisheries

Keme-Iderikumo *et al.* (2024), studying artisanal fisheries in the Taylor Creek watershed, documented that gas flaring and associated pollution had produced sharp reductions in fish catch, local extinction of certain species, increased incidental mortality, disrupted spawning, fish migration out of contaminated areas, and progressive abandonment of the fishing sector by artisanal fishers. All 120 fishers surveyed confirmed that gas flaring had significantly reduced their income; 113 confirmed observing fish deaths in the creek (Keme-Iderikumo *et al.*, 2024).

Although this study focused on gas flaring impacts, the physiological mechanisms of harm, including thermal stress, chemical toxicity, oxygen depletion, and reproductive disruption, closely parallel those associated with microplastic contamination. In the Taylor Creek system it is plausible that both stressors operate concurrently. The population-level abundance declines documented, including local species extinctions, are likely to be more severe in areas where microplastic contamination is layered on top of the existing hydrocarbon and flaring burden.

6.0 Food Safety Risks from Microplastic-Contaminated Fish

6.1 Human Exposure Pathways via Fish Consumption

Fish consumption is the most significant dietary route of human microplastic exposure in the Niger Delta. Seafood supplies approximately 20% of the global protein intake for three billion people; in the Niger Delta and broader southern Nigeria, fish from local water bodies supplies an even higher share of dietary animal protein for low-income households that cannot afford poultry, beef, or preserved fish imported from other regions (Uzomah *et al.*, 2021; FAO, 2022). Artisanal fishers and their families often eat the smallest and most contaminated fish not sold at market, frequently whole including organs, and so face the highest dietary exposure.

Global evidence establishes that human exposure to microplastics through seafood is substantial. Studies estimate that an average adult may consume approximately 2,000 microplastic particles per year through dietary salt alone, with total annual intake reaching tens of thousands of particles when seafood, drinking water, and other vectors are included. Particles smaller than 150 micrometres can translocate across the intestinal epithelium, enter the bloodstream, and distribute to organs including the liver, spleen, kidney, and lungs.

6.2 Toxicological Effects on Human Health

The toxicological effects of microplastic ingestion on humans operate through three mechanisms: physical effects of the particles themselves, chemical toxicity from plastic additives leaching from the polymer matrix, and pollutant delivery from adsorbed co-contaminants. Physical effects include inflammatory responses in gastrointestinal tissues, disruption of the gut microbiome, and potential interference with nutrient absorption and gut barrier integrity (Bora *et al.*, 2024). Chemical effects from additives, including phthalate plasticisers, bisphenol A (BPA), and flame retardants, are associated with endocrine disruption with documented impacts on reproductive hormone profiles, thyroid function, and metabolic regulation (Kumar, 2026; Zurub *et al.*, 2024).

BPA, widely used in polycarbonate plastics and epoxy resins, has been detected in tuna, pork, and tap water globally. Urinary BPA concentrations in human populations are negatively associated with inhibin B levels and the estradiol-to-testosterone ratio, indicating measurable disruption of male reproductive hormone balance (Zurub *et al.*, 2024). Phthalates display anti-androgenic activity and are associated with reduced semen quality, gestational complications, and disruption of foetal development. Prenatal POP exposure, which may occur through fish consumption in the Niger Delta, is associated with decreased birth weight, childhood obesity, elevated blood pressure, and endocrine disruption (Kumar, 2026).

Beyond endocrine effects, ingested microplastics deliver adsorbed carcinogenic compounds, notably PAHs, to gastrointestinal tissues. Omokpariola *et al.* (2025) documented epidemiological evidence of elevated lung, skin, and liver cancer incidence among populations near Niger Delta oil production sites, attributing this to chronic PAH and volatile organic compound exposure. If microplastic ingestion through fish consumption adds a further PAH exposure route for these same populations, microplastic contamination of the food chain may be contributing to the cancer burden in the Niger Delta in ways that current monitoring does not capture.

Immune suppression represents a further concern. Omokpariola *et al.* (2025) found that increasing POP exposure weakens immune function, raising susceptibility to infectious disease while simultaneously increasing the burden of non-communicable conditions including COPD, diabetes, chronic kidney disease, and neurological disorders. Microplastics, by delivering POPs and other immunotoxic compounds to consumers, may worsen the immunological vulnerability of Niger Delta communities already exposed to multiple environmental stressors.

6.3 Antimicrobial Resistance as an Emerging Food Safety Concern

A more recent concern is the ability of plastic surfaces to harbour antibiotic-resistant microorganisms. The plastisphere, the community of microorganisms that colonises microplastic surfaces, is enriched in antibiotic resistance genes (ARGs) relative to surrounding water column communities (Tuvo *et al.*, 2023; ScienceDirect, 2025). Fish that ingest microplastics colonised by ARG-carrying bacteria may allow these organisms to colonise the gut and transfer resistance genes to commensal bacteria. For consumers of Niger Delta fish, this pathway extends food safety risk beyond chemical toxicity into infectious disease risk. Nigeria's healthcare system already faces significant antimicrobial resistance challenges; contaminated Niger Delta fish as a potential vehicle for resistance gene transfer adds a further dimension to the case for microplastic contamination control.

6.4 Nigerian Regulatory Framework and Its Gaps

Food safety oversight of Nigerian fisheries products rests primarily with the National Agency for Food and Drug Administration and Control (NAFDAC) and the Federal Ministry of Agriculture and Food Security, with environmental oversight from NESREA and the National Oil Spill Detection and Response Agency (NOSDRA). Existing maximum residue limits (MRLs) for chemical contaminants in fish products address pesticide residues and heavy metals; no Nigerian-specific MRLs exist for microplastics or their associated additive chemicals (Uzomah *et al.*, 2021; Ekpo, 2023).

This gap has real consequences. Uzomah *et al.* (2021), in a systematic review of chemical contaminants in Nigerian marine and freshwater fish, identified microplastics among detected contaminants but noted the absence of enforceable monitoring standards, making compliance assessment impossible. Without routine microplastic monitoring in fish destined for domestic markets, Nigerian consumers have no means of gauging the microplastic content of what they purchase, and producers face no market-based incentive to reduce contamination.

7.0 Implications for Sustainable Fisheries Financing in Nigeria

7.1 The Fisheries Financing Landscape in Nigeria

Nigeria's fisheries sector operates against a structural production deficit. The country produces approximately 800,000 to 1,000,000 metric tonnes of fish annually against domestic demand estimated at over 3 million metric tonnes, with the gap filled through large-scale imports. Artisanal fisheries, which dominate production in the Niger Delta, account for approximately 80% of domestic output but suffer from chronic underinvestment, poor access to credit, outdated technology, inadequate post-harvest infrastructure, and weak linkages to formal financial systems.

Several public and development finance institutions have identified fisheries as a priority investment sector in Nigeria, including the Bank of Agriculture, the Agricultural Credit Guarantee Scheme Fund, the Nigeria Incentive-Based Risk Sharing System for Agricultural Lending, the African Development Bank, and the International Fund for Agricultural Development. Environmental, Social, and Governance (ESG) considerations are now standard elements of fisheries sector due diligence for international lenders, making environmental contamination risk directly relevant to financing decisions.

7.2 Microplastic Contamination as a Material Financial Risk

Significant microplastic contamination in Niger Delta fish creates material financial risk for fisheries enterprises and their investors, lenders, and insurers through several mechanisms. The most immediate is market risk: documented contamination in fish from a production area can trigger market withdrawal, import bans, and consumer aversion that sharply reduce commercial value. For export-oriented Nigerian fisheries businesses, EU and Asian market access depends on compliance with increasingly stringent food safety standards; detection of microplastic contamination above emerging threshold levels could close export markets.

Regulatory risk is the second mechanism. As scientific consensus on microplastic toxicity solidifies and governments enact new frameworks, Niger Delta fisheries enterprises face prospective compliance costs, including water quality investment, microplastic monitoring systems, product testing, and possible production relocation or diversification. These represent contingent liabilities that sophisticated investors are increasingly required to factor into credit risk and ESG assessments.

Reputational risk affects not just individual enterprises but the Niger Delta fisheries brand as a whole. Given extensive international coverage of Niger Delta environmental degradation, including sustained documentation by Amnesty International of oil pollution impacts on fisheries and human health, and high-profile corporate accountability proceedings against Shell (Amnesty International, 2024), any publication linking Niger Delta fish to microplastic contamination would deepen the reputational damage that already affects the region's products in international markets.

Productivity risk directly affects enterprise revenues. Artisanal fishers in the Niger Delta are already experiencing sharp catch reductions, local species extinctions, and increased effort per catch in a petrochemically degraded environment (Keme-Iderikumo *et al.*, 2024). To the extent that microplastic contamination worsens these trends through its effects on fish growth, reproduction, and behaviour, it further erodes the biological productivity on which fisheries revenues depend.

7.3 The Financing Gap and How Contamination Deepens It

Artisanal fishers in the Niger Delta face a financing gap rooted in enterprise informality, lack of collateral, income seasonality, and absence of financial records. Lenders that might consider fisheries enterprises in less-contaminated environments face an additional deterrent in the Niger Delta: the difficulty of separating legitimate credit risk from the systemic risk created by environmental contamination. A lender evaluating a loan to a fish farmer or aggregator in Rivers State must assess not only individual creditworthiness but also the environmental quality of the water used for production and the likely regulatory trajectory of food safety requirements for the species being produced.

Without systematic microplastic monitoring data, this environmental risk assessment cannot be conducted rigorously. Risk-averse lenders respond by declining credit or applying risk premiums that make borrowing unaffordable for small-scale operators. The resulting credit constraint perpetuates low technology adoption, limits the scale of sustainable aquaculture development that could substitute for contaminated wild-capture fisheries, and prevents the sector from attracting the equity investment needed to upgrade value chains and expand market access.

7.4 Green Finance, Blue Economy, and the Role of Environmental Remediation

The blue economy framework, which seeks to position sustainable ocean-based industries including fisheries as investment-grade contributors to climate resilience and food security, has attracted growing interest from green bond issuers, impact investors, and sovereign wealth funds. Nigeria's federal government has expressed interest in positioning the Niger Delta as a contributor to the blue economy through sustainable fisheries development and ecosystem restoration. The credibility of this investment case is, however, fundamentally undermined by the failure to address baseline environmental contamination, including the microplastic dimension.

Global fisheries and aquaculture investment frameworks increasingly require environmental impact assessments, water quality certification, and supply chain traceability as conditions for access to green financing. Niger Delta fisheries enterprises that cannot demonstrate compliance with basic environmental quality standards will be excluded from the premium financing terms associated with certified sustainable or blue economy investments. Enterprises that invest proactively in contamination assessment, mitigation technology, and independent certification stand to benefit from preferential access to green finance and premium-price international markets.

8.0 Policy Recommendations and the Path Forward

8.1 Strengthening Environmental Monitoring and Research

The most basic prerequisite for addressing microplastic contamination in Niger Delta fisheries is a systematic, government-supported monitoring programme covering regular sampling of water, sediment, and fish tissue across all major waterways and estuaries for microplastic abundance, polymer type distribution, and associated co-contaminant loads. Data should be publicly accessible in formats usable by investors, regulators, insurers, and civil society organisations. Establishing a Niger Delta Microplastics Monitoring Consortium, bringing together federal and state environmental agencies, Nigerian universities, and international research partners, would provide the institutional framework this requires.

Research priorities should include the first comprehensive species-level assessment of microplastic accumulation in commercially important Niger Delta fish across tissue types and seasonal cycles, ecological risk assessments integrating microplastic and co-contaminant burdens using validated indices such as PERI and PLI, as applied by Chris and Anyanwu (2023) for toxic metals, and epidemiological studies examining microplastic-related health outcomes in fish-consuming Niger Delta communities. These would fill a critical gap in understanding the actual human health burden of microplastic contamination in the region.

8.2 Regulatory Reform and Food Safety Standards

NAFDAC and NESREA should develop and implement maximum residue limits and monitoring protocols for microplastics and key plastic-associated chemicals, including phthalates, BPA, and priority PAHs, in fish products destined for Nigerian domestic markets. Aligning Nigerian food safety standards with Codex Alimentarius Commission guidelines and emerging European Food Safety Authority recommendations for microplastics in food would strengthen domestic consumer protection and improve the export market access prospects of Nigerian fisheries products.

The Nigerian Upstream Petroleum Regulatory Commission and NOSDRA should be required to include microplastic contamination assessment in all environmental impact assessments for new oil and gas development projects in the Niger Delta, and to incorporate microplastic remediation requirements into existing clean-up orders for contaminated sites. Oil companies operating in the Niger Delta should be required to fund microplastic monitoring programmes under their community development and environmental responsibility obligations pursuant to the Petroleum Industry Act (2021).

8.3 Integration of Environmental Risk into Fisheries Financing Frameworks

NIRSAL, the Bank of Agriculture, and federal and state agricultural development programmes should develop standardized environmental contamination risk assessment frameworks for fisheries credit decisions. These frameworks should incorporate water quality and microplastic contamination assessments as standard elements of loan due diligence for fisheries enterprises in high-risk areas including the Niger Delta. Offering preferential interest rates to enterprises in environments certified as meeting minimum environmental quality standards would create market incentives for producers to invest in contamination monitoring and mitigation.

Development finance institutions operating in Nigeria, including the African Development Bank, IFC, and IFAD, should develop dedicated technical assistance programmes to support Niger Delta fisheries enterprises in achieving environmental certification, accessing ESG-aligned finance, and building the operational capacity needed to meet evolving international food safety standards. This assistance should include support for investment in recirculating aquaculture systems and other controlled-environment production technologies that can insulate cultured fish from ambient microplastic contamination in open water bodies.

8.4 Plastic Waste Management and Source Reduction

Addressing microplastic contamination in Niger Delta fish requires upstream interventions in plastic waste management, not only downstream monitoring of fish products. The federal government should accelerate implementation of Nigeria's National Plastic Action Partnership commitments and the Single-Use Plastics Regulation, with specific enforcement focus on plastic waste disposal in Niger Delta watersheds. Investment in waste collection infrastructure in riverine communities, including community-based plastic waste collection schemes, river clean-up operations, and material recovery facilities, would reduce the plastic litter load entering Niger Delta water bodies over time.

The fisheries sector should be actively engaged in plastic pollution reduction. Promoting biodegradable and low-fragmentation fishing gear alternatives, establishing buy-back schemes for end-of-life synthetic nets and lines, and training artisanal fishers in responsible gear disposal would reduce the sector's own contribution to microplastic pollution. These steps align with global fisheries sustainability standards and would strengthen the ESG credentials of Niger Delta fisheries enterprises seeking access to green finance.

9.0 Conclusion

Microplastic contamination in Niger Delta fish sits at the intersection of global plastic pollution trends and a severe local ecological crisis. The Niger Delta's water bodies, already compromised by decades of petroleum contamination, heavy metal accumulation, and gas flaring, are significantly contaminated with microplastics from inadequate solid waste management, degrading fishing gear, petroleum industry plastics, and upstream riverine transport. Commercially important fish species are accumulating microplastics in their gastrointestinal tracts, gills, and other tissues, thereby also accumulating and transmitting carcinogenic PAHs, endocrine-disrupting plasticisers, heavy metals, and antibiotic-resistant microorganisms to human consumers.

The food safety consequences for a population that depends heavily on Niger Delta fish as a primary protein source are serious, and particularly so for low-income and rural households with the least access to information about contamination or to protein alternatives. The health effects of chronic microplastic ingestion, spanning endocrine disruption, reproductive impairment, immune suppression, organ toxicity, and elevated cancer risk, compound the health burdens already borne by Niger Delta communities exposed to petroleum contamination.

Equally important, and largely unaddressed in both the environmental and financial literature, is what microplastic contamination means for fisheries financing in Nigeria. Contamination-related market risk, regulatory risk, reputational risk, and productivity loss together constitute a material financial risk to Niger Delta fisheries enterprises, and their inadequate quantification perpetuates the credit gap that prevents the sector from attracting the investment necessary for sustainable development. Addressing the nexus between ecological contamination, food safety, and development finance requires a coordinated policy response: stronger environmental monitoring, reformed food safety regulation, contamination risk integration into fisheries lending frameworks, and upstream plastic waste reduction at the watershed scale. The Niger Delta's fisheries are a resource the region cannot afford to lose.

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