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Research on the Institutional Supply for Rural Ecological Environment Governance in the Context of Rural Revitalization

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Abstract: China's Rural Revitalization Strategy and the accelerated pursuit of agricultural modernization have raised the ecological stakes of rural development: environmental quality is not only a condition for sustainable agricultural production but also a determinant of public health and everyday rural well-being. Yet rural pollution is increasingly generated through the cumulative effects of routine human decisions - household disposal and sanitation practices, farmers' input management under yield risk, and enterprises' compliance choices - within governance settings where pollution is often non-point, cumulative, and difficult to attribute. This article examines rural ecological environmental governance as a problem of institutional supply, asking how legal and regulatory arrangements can better match the behavioral and biophysical realities of rural China. Drawing on policy-text analysis, doctrinal review of environmental laws and regulations, and illustrative case observation, the article maps three interlinked pollution domains - domestic solid waste, agriculture-related non-point and cumulative pollution, and untreated wastewater combined with township industrial discharges - and diagnoses why governance outcomes remain fragile. The analysis identifies a reinforcing causal structure: actor-level incentives and limited awareness sustain harmful routines; governance responsibilities and oversight capacity are fragmented; infrastructure is undermined by underinvestment and, critically, unstable operation-and-maintenance financing; and the existing legal toolkit remains insufficiently specific for rural contexts, especially for cumulative pollution, creating situations where harms occur without clear, directly applicable legal bases for accountability and remedies. The article proposes an integrated legal-institutional response that links education and professionalized grassroots enforcement with social oversight, secures dedicated investment and performance-oriented supervision for rural waste and sewage systems, and strengthens rural-facing rules either through a dedicated rural environmental law or through systematic rural provisions within the Environmental Protection Law, supported by measurable indicators for implementation and evaluation.

Keywords: Rural ecological environment, Environmental law, Environmental protection

1. Introduction

As a major agricultural nation and the world's largest producer and exporter of agricultural products, China has witnessed rapid improvements in agricultural production technologies in recent years, propelled by economic growth and technological change (Chen et al., 2025; Dai & Yang, 2024). Contemporary policy discourse elevates this trajectory: the 20th National Congress of the Communist Party of China called for accelerating the construction of an agricultural powerhouse, and General Secretary Xi Jinping has framed agricultural modernization as foundational to high-quality development, arguing that "an agricultural powerhouse is the foundation of a modern socialist powerhouse, and advancing agricultural modernization is an essential requirement for achieving high-quality development" (Cui & Shoemaker, 2018). From a development perspective, the centrality of agriculture to growth, structural transformation and living-standard improvements is well established, particularly in contexts where rural areas remain the broadest social foundation and the locus of both development constraints and potential (Fan et al., 2025; Gollin et al., 2013). Yet agricultural modernization is inseparable from the biophysical systems that sustain it: intensification and technological upgrading can simultaneously raise yields and widen environmental externalities, including nutrient losses, soil degradation and freshwater contamination, which ultimately feed back into rural livelihoods and the stability of food systems (Poore & Nemecek, 2018). This tension is especially salient under the rural revitalization strategy proposed by Xi Jinping in 2017 in the report to the 19th National Congress of the Communist Party of China (Liu & Li, 2017). In that framing, the countryside is a regional complex with intertwined natural, social and economic characteristics and multiple functions—production, living, ecology and culture—so environmental quality is not a peripheral concern but a constitutive condition for sustainable rural development (Daniel et al., 2012). Policy narratives further stress that China remains in the primary stage of socialism, and that the most arduous tasks, broadest foundation and greatest potential for building a moderately prosperous society in all respects and a modern socialist country lie in the countryside; on this view, rural revitalization carries not only immediate practical value but also long-term historical significance (Long et al., 2020). Within the articulated "seven paths" for rural revitalization with Chinese characteristics, one explicitly calls for harmonious coexistence between humanity and nature and for taking a path of green rural development, alongside an objective to prioritize ecological civilization construction in rural areas; consistent with the principle that "lucid waters and lush mountains are invaluable assets," this implies that protecting rural ecosystems is integral to modernization rather than an afterthought (Cheung et al., 2023).

However, translating macro-level strategies into measurable ecological improvements requires more than technological progress or rhetorical commitment; it demands institutional arrangements that can reshape everyday human behavior in dispersed rural settings (Ostrom, 2009). Rural environmental problems often exhibit the hallmarks of complex social–ecological systems: diffuse sources of pollution, cumulative and lagged impacts, cross-scale spillovers, and governance tasks that are fragmented across households, villages, enterprises and multiple levels of government (Folke et al., 2007). Such conditions intensify classic collective-action and monitoring dilemmas, making "institutional fit"—the alignment of rules, responsibilities and enforcement capacity with the attributes of the ecological problem—decisive for policy effectiveness (Epstein et al., 2015). In China, the challenge is compounded by the uneven geography of administrative capacity and the well-documented gap between ambitious environmental targets and local implementation, especially

where governance must reach into routine practices rather than a limited number of identifiable point sources (Ran, 2017). Because these governance challenges are fundamentally institutional, laws and regulations are indispensable to rural environmental protection; yet, although China has enacted the Environmental Protection Law and expanded the broader environmental legal system, existing statutory and regulatory toolkits remain comparatively sparse and less tailored for rural environmental governance, where pollution is more often cumulative, non-point and embedded in livelihoods, leaving rural communities with fewer clear, directly applicable legal bases and weaker institutional support to prevent, monitor and remedy ecological degradation in the course of rural revitalization (Kostka, 2016).

Against this background, this article examines rural ecological environmental governance as a problem of institutional supply under the rural revitalization strategy, with a specific focus on how legal and regulatory institutions can better match the behavioral and ecological realities of rural China (Huang et al., 2024). The analysis is guided by three questions: which institutional bottlenecks most constrain rural ecological protection as agricultural modernization and rural development accelerate; why do existing legal instruments struggle to govern the combined patterns of non-point and cumulative pollution and the multi-actor responsibility structures typical of rural areas; and how can an integrated "legislation–enforcement–finance–public participation" package be designed to shift incentives, strengthen compliance and enable durable collective action while respecting local diversity (Atta & Sharifi, 2024). By treating law not only as a set of prohibitions but also as an institutional architecture that shapes information, norms, incentives and accountability, the article argues that developing and refining rural environmental protection laws is necessary both to advance China's rule-of-law trajectory and to meet the ecological and environmental protection requirements embedded in rural revitalization and green rural development (Gunningham, 2009). The remainder of the article proceeds by first mapping the salient patterns of rural environmental pressures and the governance attributes that make them difficult to manage, then diagnosing the institutional gaps in current legal and administrative arrangements, and finally proposing a set of institutional-supply pathways that connect legislative design, grassroots enforcement, stable financing and participatory mechanisms to the goal of building an ecologically livable countryside (Patterson & Beunen, 2019).

2. Current Situation of Rural Pollution

The rural environment provides the biophysical foundation for farmers' livelihoods and for rural development. Incorporating data-driven decision-making the spatial diversity of rural China (Lazer et al., 2009; Lazer et al., 2020; Liu et al., 2025). Market-connected plains and more remote mountainous or arid areas often face different dominant pollution pressures, and clustered villages differ from dispersed hamlets in how easily pollution can be observed, collected, and treated (Liu, 2008; Liu & Li, 2024).Against this background, rural pollution pressures can be analytically organized into three interlinked domains that directly affect daily life and rural ecological security: domestic solid waste, agriculture-related non-point and cumulative pollution, and untreated wastewater combined with industrial discharges (Angelsen et al., 2014).

2.1 Domestic Waste Pollution

Domestic waste pollution is closely tied to rising rural consumption and changing material use, which have increased the presence of kitchen waste, plastics and packaging, and discarded household items (including

bulky goods and, in some contexts, end-of-life appliances) in village waste streams (Guerrero et al., 2013). Where collection systems and formal disposal capacity remain limited, households and communities often rely on practices such as open piling, simple landfilling, and informal dumping, behaviors that are understandable under constraints of convenience and service availability but that can systematically degrade local environments when repeated across space and time (Hincapié et al., 2015). These practices can generate immediate nuisances—visual intrusion, odors and vector breeding—and longer-term ecological risks through the production of leachate and the mobilization of contaminants into soils, especially when waste is stored or buried without liners, drainage or monitoring (Ramzan et al., 2023). A particularly salient feature is the persistence of plastics: many plastic products do not biodegrade on human time scales and can remain in the environment for decades, fragmenting into smaller particles that are increasingly recognized as pervasive contaminants with potential pathways of exposure for humans and biota. When domestic waste occupies vacant land or edges of cultivated plots, it can directly displace land from productive use and can indirectly impair soil quality; once pollutants have migrated into soils, subsequent planting may face constraints on crop growth and yield, depending on the type and concentration of contaminants present. Through food-chain and environmental exposure pathways, chronic contact with certain hazardous substances associated with poorly managed waste and contaminated soils can plausibly elevate health risks, including for some metals and persistent toxicants that have been linked in epidemiological and toxicological research to increased risks of chronic disease, including cancer, even though the magnitude of risk is contingent on the exposure profile and local conditions (Guerrero et al., 2013; Zhang et al., 2023).

2.2 Agricultural Pollution

Agricultural production is a second major source of rural environmental pressure, and its distinctive feature is that pollution often arises not from a single discharge point but from diffuse and cumulative losses distributed across fields and seasons. Fertilizers are central to crop production and can increase yields and quality, but excessive application of synthetic nitrogen and phosphorus can degrade soils and reduce long-term productivity while also generating off-site water pollution through runoff, erosion and leaching into groundwater and nearby streams (Tilman et al., 2002). Once reactive nutrients enter surface waters, they can drive eutrophication and stimulate excessive algal growth, including cyanobacterial blooms, which disrupt aquatic ecosystem balance and impair water quality. Agricultural nitrogen also has an atmospheric dimension: volatilization and subsequent deposition can alter nitrogen cycling, and the formation and transformation of reactive nitrogen compounds can contribute to air pollution and acidification, illustrating how local farm-level practices can propagate cross-media environmental impacts (Parambil-Peedika et al., 2025). Importantly, the rural pollution profile is broader than fertilizer overuse alone. Pesticide residues, livestock and poultry manure and wastewater, and plastic film residues from mulching are widely discussed in the environmental science literature as common agricultural stressors; they are often dispersed, intermittently released and difficult to attribute to a single actor, which makes them governance-relevant precisely because they are embedded in routine production behavior. Crop straw handling is another salient pressure point: where straw is not effectively utilized, piling and open burning can occur, producing smoke, aerosols and trace gases that can degrade local air quality and generate broader atmospheric impacts (Pinakana et al., 2024; Zhang, Ao, et al., 2024; Zhang, Harris Ao, et al., 2024). These pollution sources also connect to human health and living environments through multiple pathways: exposure to certain pesticides and industrially relevant contaminants

has been associated with neurological, endocrine and immune effects, while long-term exposure to some metals can increase risks of chronic disease, including cancer, underscoring that "agricultural pollution" can be simultaneously an ecological and a public health concern. At the same time, research on sustainable intensification and nutrient stewardship indicates that high yields are not inherently incompatible with lower pollution loads, suggesting that the persistence of high-loss practices is as much an institutional and behavioral problem as a purely technical one (Nuruzzaman et al., 2025).

2.3 Water pollution

Water pollution constitutes a third domain whose impacts on rural ecological conditions and daily well-being are particularly visible because contamination can transform local rivers, ditches and ponds from valued commons into health hazards within short periods (Wear et al., 2021). In rural China, domestic sewage remains a central challenge: in official reporting for the 13th Five-Year Plan period, the rural domestic sewage treatment rate is described as rising from 22% to 25.5%, an increase of 3.5 percentage points over five years, which implies that progress has been comparatively slow relative to the scale of need (Luo et al., 2025). More broadly, the wastewater treatment burden in rural areas is shaped by strong spatial disparities in economic capacity and by biophysical constraints; scattered settlements, complex terrain and long pipe distances increase the difficulty and cost of constructing collection networks and maintaining stable treatment performance (Ribarova et al., 2024). When sewage is discharged without collection and timely treatment, contaminants can enter rivers, irrigation canals, ponds and, through infiltration, groundwater, threatening local water security and amplifying downstream ecological risks. Rural water pollution is also intertwined with production systems: livestock wastewater and agri-food processing wastewater can add organic loads, nutrients, and pathogens, while township industrial enterprises can contribute additional industrial pollutants where pollution control capacity is weak. The rapid deterioration of water quality described in many rural settings—where clear waterways can become foul-smelling after concentrated discharges—highlights how point-source pollution can quickly overwhelm local assimilative capacity when monitoring and enforcement are limited. These realities indicate why an indicator-based description of rural water pollution is useful even at the problem-framing stage: treatment coverage and effective operation rates, compliance with discharge standards, the presence of black-odorous water bodies and risks to drinking-water sources provide measurable lenses through which institutional supply and governance performance can later be evaluated (Schwarzenbach et al., 2010).

Taken together, the current situation suggests that rural environmental pollution remains severe, and that its most consequential features—diffuse sources, cumulative effects, cross-media linkages and strong spatial heterogeneity—make it highly sensitive to institutional design (Dietz et al., 2003). Precisely because many rural pollution pressures are produced through routine behavior across numerous small actors, effective governance depends on "institutional fit": rules, responsibilities and enforcement capacities must match the ecological characteristics of pollution problems and the behavioral realities of rural life (Ostrom, 2009). Yet existing environmental governance arrangements in China, while increasingly ambitious, have long been discussed as uneven in implementation and often stronger in urban and industrial contexts than in rural settings, where directly applicable legal bases, stable financing and day-to-day enforcement capacity can be thinner (Kostka & Nahm, 2017). This matters for institutional supply under rural revitalization because, even

where some provinces have experimented with mechanisms, plans and implementation measures for rural environmental protection, the broader legal and regulatory architecture still needs to more clearly and comprehensively address rural pollution control, especially for non-point and cumulative pollution that is harder to attribute and remedy (Xie, 2016). As public attention to rural environmental quality grows, the gap between rural ecological risks and the specificity of legal rules becomes a central motivation for examining how rural environmental governance institutions—particularly legal and regulatory instruments—should be developed and adapted to rural realities.

3. Problems Existing in Rural Environmental Pollution

Observed patterns of rural pollution are sustained by a mutually reinforcing causal structure in which actor-level incentives, governance mechanisms, fiscal–operational constraints, and institutional misfit interact across scales. At the level of everyday behavior, households' decisions about disposal and sanitation are shaped by convenience, perceived salience of environmental harm, and the availability and reliability of services; where collection, separation, and safe final disposal are incomplete or intermittent, open piling, informal dumping, or "out of sight" disposal can become a predictable short-run choice whose ecological costs are externalized to shared land and water (Han et al., 2023; Jia et al., 2021). Similarly, as seen in studies of health information seeking, the availability of reliable and accessible information influences decision-making behaviors, making it more likely for individuals to engage in proactive actions that improve their environment or health. Lai et al. (2025) find that patient activation is strongly influenced by the sources of health information people access online, suggesting that better access to environmental information might similarly activate more informed and engaged environmental behaviors. In agricultural production, farmers' nutrient and chemical-use decisions are mediated by yield uncertainty and thin profit margins, which can incentivize risk-buffering through over-application; because resulting losses are diffuse, cumulative, and spatially dispersed, damages are difficult to attribute to specific actors, making compliance harder to monitor and sanction even when aggregate impacts on soils and waters are substantial (Tilman et al., 2002). Township enterprises face parallel incentives to minimize abatement expenditures when monitoring is episodic and penalties are uncertain, so concentrated discharges can rapidly overwhelm local assimilative capacity and degrade waterways within short periods, especially in small rural catchments These behavioral drivers are amplified by governance arrangements that fragment responsibilities across sectors and administrative levels and that often rely on target-setting or campaign-style interventions, creating gaps in routine supervision, information flows, and accountability precisely where rural environmental outcomes depend on repeated, everyday actions rather than a small number of easily identifiable point sources (Ostrom, 2009). Fiscal and operational realities then tighten the trap: rural environmental infrastructure is vulnerable to a "build–neglect" cycle in which initial construction is not matched by stable financing for operation and maintenance, leaving facilities underperforming or idle and weakening public trust, willingness to pay, and behavioral compliance.

Ultimately, the deepest driver is institutional fit: when legal and regulatory instruments are designed primarily for urban, point-source, and acute pollution events, they tend to under-specify the rules needed for rural contexts dominated by non-point and cumulative pressures—what rules are missing, who is responsible for what, how monitoring and enforcement will be sustained, where recurring O&M funds will come from, and what costs and liabilities attach to inaction (Koontz, 2021). Without institutions that align incentives and

responsibilities with the biophysical and behavioral realities of rural life, the costs of "not doing"—ecosystem degradation, heightened health risks, downstream remediation burdens, and the erosion of the ecological foundation for rural revitalization—remain socially distributed, while responsibility stays ambiguous, leaving environmentally harmful practices individually rational yet collectively damaging (Taylor et al., 2016). Wu et al. (2025) discuss how access to multiple sources of information can significantly influence lifestyle choices and behaviors, which could similarly enhance environmental compliance and action in rural settings

At the actor level, rural environmental pollution is closely linked to everyday choices made under uneven education, information, and incentives. Differences in lifestyle and educational attainment between rural and urban areas contribute to weaker environmental awareness among rural residents, and this is compounded by the scarcity of enforcement agencies that can routinely supervise day-to-day pollution (Yang et al., 2025). In the absence of visible monitoring and credible penalties, many residents remain insufficiently aware of how pollution affects their own living environment or of the legal consequences that may follow, and environmentally harmful practices can persist as "normal" behavior. Changsheng Village in Changji City, Xinjiang, illustrates this dynamic: despite convenient transportation and favorable natural and geographic conditions, the village's development has been constrained by environmental problems that largely stem from waste pollution associated with rural production activities and long-standing, outdated lifestyles (Shen et al., 2019). Over time, practices such as indiscriminate dumping of waste, uncontrolled sewage discharge, free-range livestock, and unregulated construction have accumulated into an annual waste burden that degrades the local environment and damages the village's image. More broadly, long-running lags in rural economic and cultural development mean that many farmers understandably prioritize meeting basic needs and then pursuing income growth, while local governments often place production and economic development at the center of governance and give less sustained attention to environmental protection. As economic and technological change accelerates, industrialization can further intensify rural pollution pressures when behavioral and governance adaptations do not keep pace. A vivid example is straw burning: crop straw accounts for more than half of total crop yield and represents a substantial, directly usable organic resource, yet it is often left unused, piled up, or burned. This pattern reflects high consumption, high pollution, and low utilization, wasting resources while increasing sulfur dioxide and suspended particulates in the atmosphere, seriously degrading air quality and harming rural environmental conditions (Liu et al., 2020). When such environmental issues are neglected over long periods, the consequences can become severe, ultimately undermining the ecological foundations on which agricultural development depends.

At the governance-mechanism level, weak environmental infrastructure and fragile financing arrangements translate environmental goals into implementation failure. In many rural areas, insufficient investment leaves basic facilities—especially those needed for pollution control—underbuilt, and even where funding exists, there is no guarantee that resources are used effectively for their intended purpose (Stapel, 2011). Without a dedicated body to oversee investment quality and ensure that infrastructure spending is targeted and well-managed, facilities may be constructed without the institutional capacity needed for sustained performance, limiting their contribution to environmental governance. This challenge is clear in wastewater governance: in 2021, national investment in rural domestic sewage treatment facilities totaled 69.32 billion yuan, with per capita investment at 81.16 yuan, whereas urban domestic sewage treatment facilities received 121.96 billion yuan, with per capita investment at 208.14 yuan (Tomei et al., 2016). Rural total investment therefore

amounted to 56.84% of the urban level, while rural per capita investment was only 38.99% of the urban level. Existing statistics and estimates from county-level specialized plans suggest that meeting short-term planning goals (2020–2025) would require annual construction investment exceeding 70 billion yuan nationwide, with operating costs exceeding 3 billion yuan; at the 2021 investment level, construction demand still cannot be covered. As a developing country, rural areas often lack complete environmental facilities, and even under the rural revitalization strategy, upgrading infrastructure is necessarily a long-term process rather than a short-term fix. Farmers cannot reasonably bear these costs, so rural environmental governance depends on public finance across levels of government, yet fiscal conditions are often strained while the workload of rural pollution control remains heavy. Funding shortages therefore translate into delayed or incomplete construction, and even where facilities are built, the absence of sustained financial support makes it difficult to maintain stable operation. The result is a recurrent "build then stall" outcome: infrastructure falls into disrepair and becomes idle, or initial construction is followed by a funding gap that prevents facilities from meeting treatment standards.

At the institutional level, the most critical constraint is the incompleteness of the legal and regulatory framework for rural environmental pollution control (Yang et al., 2025). Although China has promulgated the Environmental Protection Law, existing provisions are largely oriented toward urban environmental protection, while regulations directly addressing rural pollution control remain limited (Rivers & Schaufele, 2015). This creates a practical vacuum: when rural environments are damaged, there may be no directly applicable legal basis for subsequent action, and without such a basis, further measures cannot proceed. Even when rural residents recognize that certain activities pollute their local environment and seek judicial remedies to protect their rights, courts are unlikely to support claims that lack a clear legal foundation. Moreover, rural environmental pollution can be understood as both sudden and cumulative. Yet much of the relevant statutory and regulatory design has focused on sudden pollution incidents, with comparatively few provisions that speak to cumulative pollution. The consequence mirrors the broader legal gap: cumulative pollution can fall into a category where there is no legal basis and, therefore, no legal support for related claims or requests (Pontin, 2017). Overall, while legislation has been strengthened, the legal and regulatory system for preventing and controlling rural environmental pollution remains insufficiently comprehensive, leaving persistent risks that governance will confront "no rule to apply" situations when rural environmental harms occur.

4. Briefly describe the solutions from a legal perspective

Effective rural ecological environmental protection ultimately depends on changing the incentives, capacities, and social norms that shape everyday behavior (Allcott, 2011). Because farmers are the most direct and frequent users of rural land and water, weak environmental awareness can translate into routine disposal and production practices that cumulatively erode local ecosystems and undermine the quality of rural life. A first priority from a legal-governance perspective is therefore to make environmental harms and legal consequences salient through sustained education and public communication, while embedding environmental knowledge in schooling so that protection becomes a default expectation rather than an episodic campaign. The same behavioral shift is necessary for township enterprises, which must recognize that rural development cannot be built on unchecked environmental externalities (Escobar et al., 2020). However, awareness alone is

insufficient if supervision is thin and accountability is uncertain. Grassroots enforcement personnel must have both the mandate and the competence to identify pollution problems, report them promptly, investigate causes, propose corrective measures, and impose penalties within their statutory authority; targeted training is essential where personnel lack environmental awareness or professional expertise, so enforcement is credible rather than symbolic (Zhao et al., 2024). Local environmental organizations can further strengthen this behavioral–institutional linkage by helping residents understand their rights and obligations, assisting with judicial procedures when environmental disputes arise, and exercising social oversight—monitoring not only environmentally harmful behavior but also the performance of law enforcement personnel (Li & Song, 2024). In this way, enforcement becomes more transparent, residents' interests are better protected, and legal commitments to rural ecological improvement can be translated into daily practice.

Behavioral and enforcement reforms must be matched by functioning environmental infrastructure, because compliance is not realistic when basic services are missing or unreliable. Rural pollution control therefore requires increased investment in facilities that directly reduce pollution burdens, including safe water supply, sewage collection and treatment, and waste management systems (Jones et al., 2022). Crucially, these investments must be demonstrably directed toward environmental protection facilities rather than diverted or diluted across unrelated spending. Establishing specialized supervisory and enforcement capacity is central to making infrastructure effective: staff should be professionally trained in environmental protection and include personnel who understand how these facilities operate in practice, so that supervision covers not only construction but also performance. Routine inspections should focus on whether facilities are operating normally, whether maintenance is timely, and whether upgrades are made in line with local policies and evolving pollution pressures (Wang et al., 2024). Without such institutionalized supervision, infrastructure risks becoming underperforming or idle after initial construction, turning investment into a short-lived intervention instead of a durable improvement in rural environmental quality (van Rooyen et al., 2020).

Most fundamentally, rural environmental governance requires legal rules that are specific enough to be applied in rural contexts (Murphy & hUallacháin, 2025). China should therefore consider whether rural environmental protection is better advanced through a dedicated rural environmental law or through systematic rural provisions within the existing Environmental Protection Law. Given that the current Environmental Protection Law largely prioritizes urban environmental protection and only supplements rural issues, relying on it as the main legal basis for rural pollution control often lacks the specificity required for rural pollution realities (Leng et al., 2023). New or amended rules should be explicitly aligned with the actual patterns of rural pollution and should specify enforceable obligations and penalties for behaviors that damage the rural environment, thereby giving enforcement personnel clear legal authority in their daily work and giving residents a clearer legal basis when they seek protection through judicial channels. In particular, rural-facing provisions should clarify responsibilities and standards for common rural scenarios—such as household waste collection, transport, and final disposal; village sewage facility operation and maintenance; controls and oversight for township enterprise discharges; and governance requirements for agriculture-related pollution pressures—so that "what must be done, by whom, and under what consequences" is no longer ambiguous (Leng et al., 2023). After the promulgation of relevant laws and regulations, each region should further refine supporting policies in light of its own pollution conditions, while ensuring that the legal system is implemented strictly and consistently in rural areas. Only through a clear, applicable rule base and rigorous

implementation can the law generate credible deterrence, support effective enforcement, and sustain the smooth progress of rural ecological and environmental protection under the Rural Revitalization Strategy (Piorr, 2003).

5. Conclusion

A livable rural environment is not an optional add-on to rural revitalization; it is the ecological foundation on which agricultural development, public health, and long-term rural well-being depend. This article identifies three interlocking constraints that continue to weaken rural pollution control: behaviorally, environmental awareness among rural residents and some local actors remains insufficient and routine supervision is thin, allowing harmful practices to persist as everyday defaults (Liu et al., 2024); operationally, environmental infrastructure is undermined by underinvestment and, crucially, by fragile operation-and-maintenance arrangements that turn facilities into short-lived projects rather than durable services; institutionally, the legal and regulatory basis for rural pollution control remains incomplete and insufficiently tailored to rural realities, especially where pollution is cumulative rather than sudden, leaving governance vulnerable to "no directly applicable legal basis" situations after harm occurs. The policy implication is straightforward but urgent: rural ecological improvement cannot rely only on what local governments and villagers "should do"; it requires institutional supply that makes responsibilities explicit, supervision routine, and non-compliance consequential, so that environmental protection becomes a predictable, enforceable part of rural development rather than a discretionary goal (Huang et al., 2024).

In that sense, the three most critical legal levers highlighted in this paper are, first, to strengthen environmental education and publicity while professionalizing grassroots enforcement through training, clear reporting and investigation duties, and credible penalties, supported by local environmental organizations that can provide legal assistance and social oversight (Xie, 2016); second, to increase investment in water supply, sewage treatment, and waste management while ensuring funds are used for their intended purpose and are paired with specialized supervisory capacity to secure stable operation (Allaire et al., 2024); and third, to improve the rule base by either enacting a dedicated rural environmental law or systematically incorporating rural provisions into the Environmental Protection Law, with rules and penalties aligned to rural pollution patterns and strictly implemented through locally adapted supporting policies. This study is limited by its predominantly normative and descriptive approach and by the need for more systematic comparative evidence across regions and settlement forms; future work should therefore examine cross-regional governance differences, quantify lifecycle costs and financing arrangements for rural facilities, and evaluate implementation using measurable indicators such as the harmless treatment rate of rural solid waste, the stable operating rate of village sewage facilities, reductions in fertilizer and pesticide inputs, the elimination rate of black-odorous water bodies, and the frequency and coverage of routine enforcement inspections (Genius et al., 2012).

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