An Overview of Agricultural Pollution in Vietnam: Summary Report 2017
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Abbreviations ....................................................................................................... iii

Foreword .............................................................................................................. iv

Introduction ........................................................................................................... 1
   Commodity focus ............................................................................................. 2

Findings ................................................................................................................ 5
   Livestock sector ............................................................................................... 5
   Aquaculture sector .......................................................................................... 7
   Crops sector .................................................................................................... 10
   Public sector action to date ............................................................................ 16

Ways forward ....................................................................................................... 21

References ......................................................................................................... 23
Figures

Figure 1. Domestic food supply of all animal products.................................2
Figure 2. Vietnam’s food product rejection rate compared, 2002–2010 ..........10
Figure 3. Trends in cereals production, yield, and harvested areas, 1961–2013 ..11
Figure 4. Farm size distribution, 2001–2011 ..................................................11
Figure 5. Fertilizer application rates on rice paddy in selected Asian countries, 2010–2011..........................................................13
Figure 6. Breakdown of agricultural GHG emissions in Vietnam, 2014 estimates..........................................................16
Figure 7. Increases in Vietnam’s reported agricultural GHG emissions, 1994–2010..............................................................................16
Figure 8. Key legal measures pertaining to agro-environmental policy since 2004..............................................................................17

Tables

Table 1. Rejection of Vietnam’s fish and fishery products from its main export markets, 2002–2010.........................................................10
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASC</td>
<td>Aquaculture Stewardship Council</td>
</tr>
<tr>
<td>DARDs</td>
<td>Departments of Agriculture and Rural Development</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization</td>
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<tr>
<td>GAPs</td>
<td>Good agricultural practices</td>
</tr>
<tr>
<td>GlobalG.A.P.</td>
<td>Global Good Agricultural Practice</td>
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<td>GSO</td>
<td>General Statistics Office</td>
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<tr>
<td>MARD</td>
<td>Ministry of Agriculture and Rural Development</td>
</tr>
<tr>
<td>QCVN</td>
<td>Quy chuẩn kỹ thuật (technical regulation)</td>
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<tr>
<td>VietGAP</td>
<td>Vietnamese Good Agricultural (and Aquaculture) Practice</td>
</tr>
</tbody>
</table>
Between July 2015 and December 2016, the World Bank conducted a regional study of agricultural pollution in East Asia with a focus on China, Vietnam, and the Philippines, in cooperation with each country’s ministry of agriculture. This effort aimed to provide a broad overview of agricultural pollution associated with farming at the regional and national levels: its magnitude, impacts, and drivers, and what is being done about them. It also sought to outline potential approaches to addressing these issues going forward. In doing so, the study examined how the structural transformation of the agricultural sector and the evolving nature of agricultural production are shaping agricultural pollution issues and mitigation opportunities. It also identified knowledge gaps, pointing to directions for future research. Ministries of agriculture and environment are the intended primary audience of the study. It is also intended for development organizations, industry associations, and other actors with an interest in sustainable agriculture, and environmental health and protection.

The “study” constitutes the totality of the work and includes multiple components, including national overviews of agricultural pollution for the three focus countries, thematic working papers, and an overall synthesis report. The present report corresponds to the national overview of agricultural pollution in Vietnam, and specifically to the summary of three working papers on crops, livestock, and aquaculture systems. The overview covers water, soil, and air pollution directly associated with activities and decisions made at the farm level or its equivalent (for example, at the pond level in the case of aquaculture). It especially looks at (a) the use of fertilizers; (b) the use of pesticides; (c) other cropland management practices (including the use of plastics, the introduction of invasive species, irrigation, and land preparation practices); (d) the burning of agricultural residues; (e) animal waste management (land and aquatic species); and (f) the use of feed supplements, including antibiotics, hormones, and heavy metals in animal agriculture (land and aquatic). Environmental impacts relating to land-use change are beyond the scope of the study.

The statements made in this national overview are based on existing literature, and on national and international data sources. An earlier version of this report was circulated to stakeholders representing national government agencies, nongovernmental agencies, and research institutions, and was discussed at a stakeholder consultation workshop in Hanoi in December 2016. The report was finalized by consolidating and addressing comments from various stakeholders.
This report was written by Emilie Cassou, drawing on background reports on Vietnam’s agricultural pollution situation by Tung Xuan Dinh (on livestock pollution), Tin Hong Nguyen (on crops pollution), Cong Van Nguyen (on aquaculture pollution), and Dai Nghia Tran (on agro-environmental policy), and with contributions from Steven Jaffee, Jiang Ru, and Binh Thang Cao. The reports on livestock, crops, and aquaculture pollution are available online, along with a table of major policies (legal measures) addressing agricultural pollution.

This study was made possible with funding from the East Asia and Pacific Region Infrastructure for Growth Trust Fund, which is financed by Australia and administered by the World Bank Group.
Vietnamese agriculture has experienced remarkable growth over the past 20 years. The sector’s strong performance has propelled the country into the ranks of the top five exporters of half a dozen agricultural commodities, and contributed to poverty reduction, social stability, and significant improvements in food security. Today, however, Vietnamese agriculture is edging toward the limits of a growth model rooted more in the intensification of production systems—featuring heavy use of labor, chemicals, and natural resources—than in efficiency or value addition gains. Agricultural growth is decelerating and Vietnam’s competitiveness as a provider of bulk, undifferentiated commodities is flagging as the agricultural sector faces rising competition for labor, land, and other resources. The environmental fallout from intensification has also begun to adversely impact productivity and the position of Vietnam’s commodities in international markets.

If it is to fulfill its ambitions and remain a motor of economic development, Vietnam’s agriculture will need to start producing “more from less.” In this regard, tackling agricultural pollution represents a key challenge for Vietnam. Pollution has started to take a toll on the sector’s own resource base, potentially impacting soil fertility and yields, the effectiveness of chemicals in combating pests and disease, farmer health and productivity, environmental health, and the safety of food. Meanwhile, the wasteful use of inputs is a drag on farm profitability. The scientific evidence on the incidence and impacts of agricultural pollution in Vietnam remains limited, but more has started emerging. Meanwhile, the general population has become increasingly aware of the human and environmental health problems that agricultural pollution is generating.

Growing evidence and public concern about pollution have led the Vietnamese government to adopt a new outlook and to take measures to address the problem. At the strategic planning level, the Ministry of Agriculture and Rural Development (MARD), through its Agricultural Restructuring Plan of 2013, embraced the need to reduce the sector’s emissions and environmental impacts and outlined several specific targets. Since then, multiple agro-environmental laws and regulations have been adopted by various ministries, although their enforcement is still in early stages and geographically uneven.

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1 See Jaffee et al. 2016.
2 That is, generating more economic value and consumer and farmer welfare, while using less material inputs and human and natural resources, and reducing the sector’s environmental footprint (Jaffee et al. 2016).
3 See World Bank. 2016.
In retrospect, over much of the last two decades, the agricultural sector’s environmental performance has been subordinate to farm output expansion. And when environmental concerns have been raised, they have mostly been about forest encroachment by expanding aquaculture and cropland, that is, land-use change, and less about pollution related to farming per se. Agricultural pollution has generally received less attention, perhaps due in part to the complexity of measuring a multifaceted and spatially diffuse phenomenon. The resulting scarcity of data capturing agricultural pollution has, in turn, limited researchers’ ability to comprehensively study its impacts on such things as human and animal health, biodiversity, the profitability of farming and other industries, and the overall net societal value of agricultural production.

The research upon which this summary report is based represents the first attempt to assemble existing evidence on the nature and magnitude of agricultural pollution in Vietnam, looking across the livestock, aquaculture, and crops subsectors. It is also an attempt to shed light on the socioeconomic impacts and drivers of agricultural pollution, including the shortcomings of existing policies and programs to reign in the problem.

Commodity focus

This overview focuses on the pollution effects of production systems for a subset of agricultural commodities: pig and poultry products, and to a lesser extent cattle products; intensively farmed *Pangasius* and shrimp; and rice, maize, and coffee. This selection reflects the significance of these commodities in terms of both their economic and pollution contributions, and in some cases, an industry trajectory that could result in higher levels of pollution in the future. The selection also takes into account ongoing governmental programs currently supported by the World Bank, and thus, opportunities to immediately deepen efforts to promote sustainable agricultural intensification.

Animal agriculture (terrestrial and aquatic) was selected because it is among the country’s fastest-growing economic subsectors, and one of the country’s leading contributors to pollution. Vietnam is experiencing one of the fastest rates of growth in animal product consumption in the world (see Figure 1), and sector responsiveness to rising demand is giving rise to an expanding pollution problem. Pollution from this sector is expanding not only because of its growth, but also because of the changes in production practices and industrial organization that rapid growth has engendered.

**Figure 1. Domestic food supply of all animal products**

![Chart showing the domestic food supply of all animal products, with data for various countries and years from 2000 to 2010.](chart.png)

Source: Based on FAOSTAT Food Balance Sheets.

Pigs and poultry birds are the largest and fastest-growing livestock populations and generate the most, and most concentrated, wastes. The businesses that hold these animals have gone far down the path of industrialization, a shift characterized in part by increased throughput and greater reliance on commercial feed and pharmaceuticals. While some of this has gone hand in hand with the emergence of larger-scale operations (in 2015, semi-industrial and industrial production accounted for 64 percent of the livestock subsector’s total output [Nguyen D. V. 2015]), industrialization has also progressed within the dense clusters of small livestock farms that have formed around populous consumption centers, such as Hanoi and Ho Chi Minh City. Today, both large and small operations pose an alarming pollution problem. The regions generating the most animal...
waste are the Red River Delta, the South East, and the Mekong Delta.

Most cattle and buffalo continue to be raised in extensive, low-intensity systems, and the wastes they generate have yet to cause major environmental problems. This is despite the fact that, as of 2014, over 80 percent of cows lived in just six of Vietnam’s 63 provinces and central cities.4 However, this situation is changing with the emergence of large-scale, commercial dairy and beef operations. The manure generated by some of the commercial dairy farms being established near big and midsized cities such as Hanoi, Ho Chi Minh City, and Vinh in Nghe An province (South Central Coast) already exceeds the land’s nutrient load capacity (Lê 2012; Duteurtre et al. 2015), and the regulations in place to protect groundwater and surface water from contamination are only weakly applied.

In relation to fisheries, aquaculture is not only on a path of much steeper growth than capture fisheries, but is also the larger polluter of the two fisheries subsectors due to the use of large quantities of feed and pharmaceuticals. (It is difficult, with limited data, to compare levels of pollution generated by aquaculture and livestock—an issue that warrants further discussion.) Within the aquaculture sector, Pangasius and shrimp production both have large spatial and environmental footprints; the area they occupy (especially shrimp5) and their intensity having both grown significantly over the last 10 to 15 years. The key region in terms of aquaculture production is the Mekong Delta, which accounted for over 70 percent of the farmed area and output in 2013 (based on General Statistics Office [GSO] data). The Red River Delta and the North Central and Central Coasts occupy a distant second and third position.

Rice is Vietnam’s leading food staple and continues to account for most of the area under crops. And the Mekong Delta—where half of national rice production and 90 percent of rice exports originate6—is the country’s rice basket. The Red River Delta is a distant second (and declining) contributor to rice output. Rice paddy production accounts for the largest proportion of Vietnam’s use of fertilizer and pesticides, with coffee and maize ranking a distant second and third in the use of these inputs (based on GSO data).

Maize ranks second in terms of its planted area in Vietnam. While previously grown primarily for food in upland areas, over 80 percent of national maize production is now estimated to be used for animal feed (for both livestock and aquaculture operations) (Nguyen T. H. 2017). Maize production occurs throughout the country. The North West, North East, and Central Highlands regions account for around 60 percent of total output, and the most intensive production occurs in the Central Highlands.

Coffee is one of the tree crops for which Vietnam has emerged as a major global supplier. Vietnam went from being a minimal player in world coffee markets at the end of the 1990s to being the second-largest global producer one decade later (based on FAOSTAT data). Almost all of it is intensively cultivated in the Central Highlands region. Coffee’s expansion and intensification have occurred in a largely uncontrolled fashion, and its environmental costs include deforestation, land degradation, and the depletion of groundwater—as well as water and soil pollution.

The research underpinning this study focused primarily on pollution arising from (a) animal feeding and supplementation practices, (b) animal waste and wastewater management practices, (c) fertilizer use, (d) pesticide use, and (e) the burning of crop residues.

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4 Hanoi, Son La, Nghe An, Lam Dong, Ho Chi Minh City, and Long An.
5 Shrimp farming occupies far more space than Pangasius does (well over 100 times more), but Pangasius is produced in higher volumes (Kam et al. 2012).
6 http://www.pecad.fas.usda.gov/highlights/2012/12/Vietnam/.
Livestock sector

Livestock production is not only growing but also industrializing and spatially concentrating—often in troublesome proximity to densely populated areas—even while remaining smallholder-dominated. This situation, which the government is trying to counteract by encouraging consolidation and spatial redistribution, has translated into a mismatch between producers’ capacity to invest in or coordinate pollution control on the one hand, and the environmentally risky industrial methods of production that have come to dominate the sector, on the other. This is in a context of weak economic incentives and limited pressure to comply with environmental regulations.

The intensification of livestock production has not lived up to its potential to lessen pressure on the environment by bringing about professionalization and gains in efficiency. Instead, it has given rise to more spatially concentrated and chemically charged waste streams. And while this may be partly due to the prevalence of small-scale farming, a shift to large-scale commercial farming may not hold the solution to the industry’s pollution problems. Even though large-scale farms invest more in waste treatment than small-scale farms, in proportional terms, the efforts of large-scale farms, including ones operating near Hanoi and Thai Binh in the Red River Delta, and Ho Chi Minh City and Dong Nai in the Mekong Delta, often fall short of what would be needed to manage the large volumes of concentrated wastes they generate.

Livestock pollution problems are most pronounced in the pig sector. Pigs generate by far the most waste in both absolute and relative terms (per animal). In geographic terms, livestock pollution problems are the most pronounced in the intensively farmed provinces of Thai Binh and Hanoi in the Red River Delta and Dong Nai in the Mekong Delta regions.

The estimated 80 million tons of livestock waste generated each year are vectors of nutrients, pathogens, and volatile compounds that compromise water and air quality and damage soils (based on DLP-MARD 2015). In pig farming, for example, around 70 to 90 percent of nitrogen, minerals (phosphorus, potassium, magnesium, and others), and heavy metals contained in feed are reportedly excreted to the environment (Dinh 2017). The level of wastewater contamination by
coliiform caused by smallholder pig farms was found to be 278 times higher than the permitted level, while that of commercial farms was 630 times higher than the permitted level in one study (Phùng et al. 2009). Concentrations of ammonia in air emissions from pig farms in the North region have been found to be 7 to 18 times higher than permitted levels, and that of hydrogen sulfide 5 to 50 times higher (Vũ 2014).

**Although laws and regulations have been adopted to prevent this situation, around 36 percent of livestock waste is estimated to be dumped into the environment untreated.** Partly due to the lack of regulatory pressure on farmers who engage in this practice, and the unattractive economics of waste treatment and recycling in many contexts (compared to dumping), this phenomenon also reflects physical and investment constraints, including a lack of access to space. Small farms—perhaps because they are less likely to attract regulatory scrutiny and also have less access to technologies and finance—dump a larger share of their wastes than their large, commercial counterparts (estimates are 40 percent compared to 16 percent).

**Meanwhile, even though the majority (approximately 64 percent) of livestock waste undergoes some form of treatment in Vietnam, much of it remains inadequately handled.** For instance, biodigesters have penetrated the industry to a large extent in Vietnam, propelled by government subsidies, and are helping to lessen climate and organic pollutants from animal wastes. However, the effluents from these digesters are often dumped untreated, thus carrying organic matter, nutrients, drugs, and feed additives like heavy metals into waterways and the environment. And while the application of livestock waste to soils as a form of fertilizer mitigates certain pollution problems by spreading the manure (thus spatially diffusing nutrient runoff), building soil organic matter that helps nutrient retention, and reducing methane emissions related to decomposition, it is frequently overapplied, causing harm to soil fertility (acidification, microbiota imbalances, heavy metal accumulation), and increasing the risk of crop contamination with pathogens. This raises potential concern about the widespread use of chicken manure as fertilizer (some 75 percent is used this way [Dinh 2017]), poultry wastes being second only to those generated by pigs.

*Both treated and untreated livestock wastes also spread the pharmaceuticals that are now systematically used in intensive pig and poultry production.* Although Vietnam-specific evidence is limited on this, chronic exposure to these pharmaceuticals is known to be harmful to health, while the abundance of antimicrobials in the environment and in organisms is known to foster microbial resistance to the life-saving drugs on which humans and animals rely. One study showed that 33 to 47 percent of E. coli isolated from colibacillosis in pigs was resistant to antibiotics such as enrofloxacin, ciprofloxacin, norfloxacin, and erythromycin (Khanh 2010). Another study found 80 percent of isolated E. coli and 77 percent of Salmonella spp. to be resistant to at least one type of antibiotic, and over 60 percent of these bacteria were resistant to two or more types of antibiotics (Phương et al. 2008 in Dinh 2017). Yet another study—this time on E. coli from the fecal samples of children living in a rural area outside of Hanoi—found 60 percent of the bacterial isolates to be resistant to three or more antibiotics (Dyar et al. 2012). Recognizing this threat, MARD (as of 2016) initiated regulatory action to reduce the use of growth-promoting antibiotics in feed.

**Wastewater from livestock farms is among the major causes of drinking water pollution affecting city dwellers, according to the Department of Natural Resources and Environment of Ho Chi Minh City.** After being discharged into canals, wastewater flows into the Saigon River, which is the main source of water supply for drinking and domestic uses in the

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7 Estimated in Dinh 2017.
8 Treatment plants in the United States have been found to remove only around half of the drugs present in wastewater (Arvai et al. 2014).
Livestock waste has now been included in the list of pollution sources that require tight control by the public authority to protect water quality in the Dong Nai-Saigon river system.

**Despite reason for concern, few studies examine the water, health, and other impacts of livestock wastes, leaving this critical problem for the media to document.** Often, news reports are spurred by residents’ complaints about the noisome odors arising from clustered livestock farms, rather than more pernicious yet less visible pollutants, such as nutrients, heavy metals, bacteria, and viruses.

There is preliminary evidence that the maintenance of poor sanitary conditions that (needlessly) worsen pollution problems are also harmful to farm productivity. Poor sanitary conditions make farms that much more susceptible to suffering from productivity losses linked to self-contamination. Evidence is preliminary, yet project-level interventions to improve the sanitary conditions and waste management practices of livestock farms have already achieved clear results in terms of productivity. For example, by introducing “good animal husbandry” practices, the World Bank-supported Livestock Competitiveness and Food Safety Project reduced rates of pig mortality from 15 to 11 percent, and poultry mortality from 41 to 33 percent in targeted areas. It also reduced fattening times from 136 to 118 days for pigs and from 66 to 58 days for poultry (reducing the amount of feed and other inputs needed to raise the farm animals, along with volumes of waste generated) (LIFSAP 2015).

Separately, the raising of livestock is a major source of climate pollution in Vietnam, and manure management the fastest-growing source of agricultural greenhouse gases, though energy and rice production are still larger sources (see Figure 6 and Figure 7). The decomposition of animal wastes gives rise to emissions of methane and nitrous oxide, both powerful greenhouse gases, especially when the concentration of wastes leads to their anaerobic decomposition. The subsector’s climate footprint is much larger, moreover, once emissions related to flatulence of ruminant animals and respiration of all animals are factored in. Farm-level, fertilizer-related emissions from the production of crops that are fed to industrially raised animals can also be attributed to livestock farming, though this does not appear in the charts below (see discussion on maize below).

**Aquaculture sector**

The rapid development of aquaculture in Vietnam over the last 15 years—especially the spread of intensive *Pangasius* and shrimp monocultures in the Mekong Delta—has given rise to increasing water pollution problems, outpacing regulators’ capacity to manage the sector’s externalities. The value of aquaculture, which is dominated by the farming of freshwater *Pangasius* and brackish water shrimp (in output terms), increased six-fold between 1995 and 2014, while that of all fisheries (aquaculture and capture) increased two-and-a-half times (based on GSO data). Strongly encouraged by the state, the industry’s expansion has been possible both through the large-scale conversion of natural ecosystems, including mangroves,11 and through intensification. Between 1995 and 2014, aquaculture production increased nearly eight-fold (in terms of tonnage), while the area devoted to aquatic farming more than doubled.12 As of 2014, the Mekong Delta housed an estimated 5,500 hectares of *Pangasius* farms and 604,000 hectares of intensive shrimp farms (Phuong et al. 2015 in Nguyen C. V. 2017), and as noted, accounted for upward of 70 percent of national aquaculture production overall (by area and tonnage).13 Most of these farming operations are

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10 Shrimp farming occupies a much larger area than *Pangasius* farming does. More than 70 percent of all area devoted to aquaculture is occupied by shrimp farms. However, *Pangasius* accounts for around half of aquaculture output by weight (http://pubs.iclarm.net/resource_centre/WF_2776.pdf).

11 According to data from Sá and Hanh (2008), total mangrove area in the Mekong Delta in 1983 was about 126,000 hectares in 1983 (mainly natural forests), 93,000 hectares in 1988; 78,000 hectares in 1992; and 27,000 hectares in 1999. This resulted from uncontrolled wood extraction and the expansion of rice and shrimp farming.

12 Based on GSO data for fish and shrimp production in 2014.

13 Based on GSO data for fish and shrimp production in 2014.
intensive and semi-intensive monocultures, and the pollution problems they give rise to are broadly due to the excessive and improper use of inputs including feed, water treatment chemicals, antibiotics, and other drugs, and to the management of effluents. These pollutants originate from a range of aquaculture production activities, or “subsystems,” including pond construction, pond treatment, water intake, stocking, nursing, water exchange, sludge discharge, harvesting, and pond emptying (Anh et al. 2010a and 2010b).

Aquaculture pollution stems mainly from the discharge of untreated wastewater into local waterbodies. As of 2014, *Pangasius* farms are estimated to have generated more than 10 billion cubic meters of wastewater containing 51,336 tons of nitrogen and 16,070 tons of phosphorus (Nguyen C. V. 2017). The vast majority of these pollutants were discharged to local canals and eventually to the Mekong Delta river system, without prior treatment, despite the fact that most rural households depend on these surface waters for drinking and other domestic uses. Estimates of water discharges related to shrimp farming are smaller. Intensive shrimp production generated an estimated 4.4 billion cubic meters of wastewater, containing 25,344 tons of nitrogen, and 6,336 tons of phosphorus (Nguyen C. V. 2017). An estimated 75 percent of these were discharged into local rivers in coastal areas of the Mekong Delta (Nguyen C. V. 2017). Looking ahead, continued growth in aquaculture production could further increase pollutant loads if major improvements in technologies and practices are not realized. If Vietnam achieves the ambitious production targets that the fisheries Master Plan of 2013 lays out for 2020, *Pangasius* production alone will increase by more than 60 percent over 2014 levels—that is, by 1.8 million tons—in large part in the Mekong Delta region.

To protect fish from pond water contaminants, aquaculture farmers commonly engage in frequent water exchange (up to daily), flushing used waters from ponds and recharging them with freshwater. As a result, the vast majority of the nutrients and additives found in feed are being released, in most cases without treatment, to pollute surface waters. In some cases, sediment is collected in sedimentation ponds, but even then, the sludge that accumulates in ponds is often released into the environment without further treatment (although it is often suitable for use as a crop fertilizer). Such practices continue even though, from a technical standpoint, viable alternatives are available. This has been demonstrated in intensive shrimp farms that have adopted (mostly) closed-loop water recirculation systems, for example. These systems require farmers to replenish only water lost to evaporation (on a weekly-to-monthly basis). While these can make business sense because they prevent outside diseases from entering, and they help farms meet the environmental performance standards of demanding markets, they require high upfront investments.

Several other factors help explain why improper wastewater and sludge management remain widespread in shrimp and *Pangasius* farming. For example, because land suitable for *Pangasius* farming in the Mekong Delta is very expensive, farmers try to minimize the area devoted to waste treatment systems such as sedimentation and wastewater treatment ponds. Meanwhile, although regulations are in place to limit water pollution, wastewater treatment is perceived by many farmers as an “encouraged practice” rather than a compulsory one. Indeed, MARD and MONRE regulations governing the treatment of wastewater have not been strictly enforced. The multiplicity of standards emitted by different regulatory agencies has also reportedly been a cause of confusion, and perhaps even noncompliance. Market incentives have seemingly done more to motivate farmers, and those seeking certification under VietGAP, GLOBALG.A.P., ASC, and eco-labels seem to demonstrate better environmental management.

In fact, demands of export markets have seemingly driven improvements in environmental management since 2010. In particular, NGOs and authorities in importing countries have periodically raised environmental concerns with Vietnam’s *Pangasius* supply chain (relating, among others, to the management of nutrients, drugs, and pesticides, and to the protection of wild species), a situation that
has potentially harmed *Pangasius* exports at times.\(^{14}\) Though claims made about the sustainability of *Pangasius* production have been disputed—and in some cases corrected on the basis of inadequate data—the controversies they have generated seem to have stimulated efforts to improve both environmental regulation as well as environmental management. As a result, a growing number of intensive *Pangasius* farms have improved their wastewater and other management practices to gain access to export markets that require certification under such standards as GLOBALG.A.P. and Aquaculture Stewardship Council (ASC). Notwithstanding progress in the *Pangasius* value chain, however, and more generally among farms participating in upgrade projects, unclear environmental standards—with different agencies issuing different standards (see below)—together with a lack of regulatory scrutiny, economic incentives, and technical, financial, and spatial capacity (especially in the case of smallholders) broadly perpetuate polluting aquaculture practices.

Under “status quo” practices, the waters and sludge that are released untreated are laden with nutrients, drugs, and chemicals. *Pangasius* farming in the Mekong Delta today is characterized by high stocking density and high feeding rates. Around 2 to 3 kilograms of feed are needed for every pound of fish, and around half of that feed is lost to pond waters either in the form of excrement or feed (De Silva et al. 2010; Nguyen C. V. 2017). These levels of feed-use efficiency reflect the widespread use of low-quality commercial feeds, though higher-quality feed does not preclude losses. Both *Pangasius* and shrimp farmers also report the systematic use of multiple antibiotics (especially enrofloxacin, amoxicillin, trimethoprim, and sulfamethoxazole), supplements (such as vitamins and digestion aides), and a host of chemicals (lime, iodine, copper sulfate, BKC, salt, ivermectin, praziquantel, chlorine, cloramin T, and Zeo-yuca in the case of *Pangasius*; calcium hypochlorite, trichlorofon, formalin/formaldehyde, potassium permanganate, saponin, potassium thiosulfate, benzalkonium chloride, iodophores, copper sulfate, humic acid, and the highly toxic dichlorvos and endosulfan in the case of shrimp) (Nguyen, T. Q. 2015; Tu et al. 2006). Though dichlorvos and endosulfan are not among the most commonly used chemicals in shrimp production (less than 4 percent of farms report using them) (Tu et al. 2006), these two chemicals are both highly toxic and are problematic even in small quantities. Endosulfan, in particular, is a persistent organochloride pesticide that is listed for elimination under the Stockholm Convention on Persistent Organic Pollutants\(^{15}\) and has been banned from use in Vietnam (Hoi, Mol, and Oosterveer et al. 2013). Various studies have confirmed that pathogens found in aquacultural products and waters have developed resistance to one or multiple antibiotics used by the industry (Thi, Dung, and Hiep 2014; Huynh, Tran, and Nguyen 2015).

Some measurements indicate that acute water pollution, overall, remains a localized phenomenon, but better measurement is needed. According to the Mekong River Commission, most of the Mekong Delta’s surface waters still broadly meet water quality guidelines for nutrients, organic waste, and acidity (with reference to its Guidelines for the Protection of Human Health and Aquatic Life) (MRC 2014). These measurements also indicate that water pollution is acute in certain areas, however, and studies confirm that certain surface waters are “dramatically degraded” (these are not specific to aquaculture) (Chea, Grenouillet, and Lek 2016). However, these water quality measurements remain sparse and incomplete, and do not tell a complete story on aquaculture’s—or agriculture’s—physical impacts on the environment, or on human and animal health. They provide no reading on water contamination with agrochemicals and drugs, for instance, or their ecological and health ramifications.

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\(^{15}\) http://chm.pops.int/TheConvention/ThePOPs/ListingofPOPs
These measurements also fail to capture several other forms of pollution. For example, aquaculture, and shrimp farming in particular, have been likely contributors to the drawing down of groundwater at unsustainable rates, leading to land subsidence and saline intrusion, especially in coastal areas of the Mekong Delta (Erban, Gorelick, and Zebker 2014; Vuong, Lam, and Van 2015). The unsustainable drawdown of groundwater resources by various users also poses a risk in relation to future freshwater availability for aquaculture and other activities. Separately, the measurement of greenhouse gas emissions from aquaculture remains at an early stage.

Food safety concerns linked to pollution have also been costly for the industry due to rejected product, and possibly due to lost sales and discounted prices—although estimates of the latter are unavailable. The contamination of aquaculture products poses a food safety issue that is only partially understood, yet Vietnam’s image as an exporter of quality has likely been blemished by export market incidents. Vietnam’s exports are much more closely scrutinized than products destined for domestic markets; and trade rejections linked to the detection of excessive levels of veterinary drugs or pathogens have been persistent in sales to Japan, the EU, Australia, and the United States. In fact, the aggregate value of Vietnam’s fish and fish product rejections by the United States, Japan, the EU, and Australia exceeded that of any other country during 2002–2010 (see Table 1). Vietnam’s food rejection rate, relative to the value of its food exports, ranged from high to medium compared to that of other countries (see Figure 2). In recent years, countries including Japan and Australia have threatened to interrupt certain aquaculture imports from Vietnam due to food safety concerns (Nguyen C. V. 2017). The potential lowering effect of food safety concerns on the price commanded by Vietnamese food exports has not been studied empirically, however. Meanwhile, because they undergo less scrutiny, aquaculture products that are sold on domestic markets are most likely less safe to consume than those headed for export.

### Table 1. Rejection of Vietnam’s fish and fishery products from its main export markets, 2002–2010

<table>
<thead>
<tr>
<th>Market</th>
<th>Value of rejections (US$ million)</th>
<th>Vietnam’s rank</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>73.0</td>
<td>#2 (after China)</td>
<td>2002–2010</td>
</tr>
<tr>
<td>Japan</td>
<td>17.6</td>
<td>#1</td>
<td>2006–2010</td>
</tr>
<tr>
<td>European Union</td>
<td>14.3</td>
<td>#2 (after Indonesia)</td>
<td>2004–2010</td>
</tr>
<tr>
<td>Australia</td>
<td>3.6</td>
<td>#2 (after China)</td>
<td>2003–2010</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>108.5</strong></td>
<td><strong>#1</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: Based on UNIDO 2015.

### Figure 2. Vietnam’s food product rejection rate compared, 2002–2010

Relative Rejection Rate Indicator (RRRI) – all food products

<table>
<thead>
<tr>
<th></th>
<th>RRRI low, first tercile</th>
<th>RRRI medium, second tercile</th>
<th>RRRI high, third tercile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>VNM</td>
<td>VNM</td>
<td>VNM</td>
</tr>
<tr>
<td>European Union</td>
<td>VNM</td>
<td>VNM</td>
<td>VNM</td>
</tr>
<tr>
<td>Japan</td>
<td>VNM</td>
<td>VNM</td>
<td>VNM</td>
</tr>
<tr>
<td>United States</td>
<td>VNM</td>
<td>VNM</td>
<td>VNM</td>
</tr>
</tbody>
</table>


Note: RRRI = ratio of a country’s share of total rejections in one market to its share of total imports into this market for the entire period (2002–2010) in this case.

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**Crops sector**

Agro-input pollution has increased dramatically in Vietnam over the last two decades together with the expansion and intensification of crop farming.

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16 Antibiotic residues were the leading cause of Vietnam’s crustacean product exports being rejected from the European Union (EU) in the decade spanning 2007–2017, followed by the presence of pathogens (based on an EU Rapid Alert System for Food and Feed query for January 2007 to April 2017 (https://webgate.ec.europa.eu/raasf-window/portal/event-searchResultList). The same applies to Vietnam’s overall agro-food exports: around 27 percent of agro-food rejection cases were due to antibiotic residues, and 23 percent were due to bacterial contamination during 2002–2010 (based on UNIDO 2015). Looking across markets, the presence of veterinary drugs accounted for 11 percent of the number of Vietnamese agro-food product rejections from the EU, the United States, and Japan during 2002–2010 (Tran et al. 2013; World Bank 2017).

17 Seafood product rejections dominated food export rejections.
Crop output rose sharply during this period both as a result of crop production’s expansion in space and its intensification (see Figure 3). The area harvested for food crops grew nearly 23 percent between 1995 and 2014, by which time it stood at nearly 9 million hectares (based on GSO data in Nguyen T. H. 2017). Whereas there has been a significant increase in land devoted to maize, cassava, coffee, and rubber since the 1990s, the area devoted to rice paddy has increased more moderately, and most recently has begun to decline (based on GSO data in Nguyen T. H. 2017). As for intensification, it has been possible through increased reliance on irrigation, agrochemicals, and improved seed (and to a lesser extent on mechanization).

- Between 1983 and 2013, fertilizer consumption increased nearly seven-fold to a peak of 26 million tons in 2013 (based on FAO data).\(^\text{18}\) Approximately two-thirds of fertilizer is used for rice; other significant uses (between 5 and 10 percent of the national total) are for maize, coffee, and rubber (multiple sources in Nguyen T. H. 2017). Growth in fertilizer use has generally slowed since 2004 (when it reached 25 million tons), and fertilizer use even declined for a few years during that decade.

- Vietnamese **pesticide use** is estimated to have increased around three- to five-fold in the space of roughly 25 years, with imports of pesticide active ingredients having gone from 20,000 to 30,000 tons per year during the 1990s to nearly 100,000 tons around 2015 (Lien T. 2015; Khanh and Thanh 2010; and Truong Q. T. 2015 in Nguyen T. H. 2017).\(^\text{19}\) The level of active ingredient per hectare, likewise, probably tripled, on average, over this period (Lien T. 2015; Khanh and Thanh 2010; and Truong Q. T. 2015 in Nguyen T. H. 2017).

An orientation toward output growth has likely contributed to farms’ heavy and often profligate use of agrochemicals. Today, it is the policy of the Vietnamese government to support a reduction in the area under rice and coffee production, compensated by continued intensification and the diversification of agricultural activities. Its focus has only recently started to shift away from production to focus more on quality, value addition, and sustainability, however. Over most of the past two decades, the state has pushed the sector to meet ambitious production targets through both intensification and spatial expansion, with limited regard for their environmental consequences. Mekong farmers’ ability to shift from one to two and sometimes three rice crops per year in the space of a few years

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18 In nitrogen, phosphorus and potassium nutrient terms.
19 In active ingredient terms.
(World Bank 2012), for example, is emblematic of what Vietnam’s environmental risk-taking has made possible. In this case, it has been based on the embrace of intensive monocultures supported by investments in closed dyke systems coupled with the use of synthetic fertilizers (needed in part to palliate the loss of alluvium), and chemical pesticides (needed in part because of the increased vulnerability of monocultures to pests). In the case of coffee, output expansion has not only relied on heavy fertilizer and irrigation, but also partly on the tree-crop’s expansion onto unsuitable land.20 This legacy has no doubt contributed to the present situation in which the majority of farmers are using more inputs than are required, not only at their own expense in terms of profitability and personal health, but also at the expense of the environment and public health.

Meanwhile, the continued dominance of small farm size—even as farming has intensified—has also potentially exacerbated pollution from crop farming. As in much of the region, intensification has not been accompanied by an increase in average farm size, and even where some consolidation has begun, farm size remains small (see Figure 4). Some consolidation, for example, has occurred in Mekong rice and to some degree in Central Highlands coffee cultivation (see Jaffee et al. 2016; Havemann et al. 2015). Even in these cases, however, the average farm remains small. The average farm size for rice is just over 1 hectare in the Mekong Delta, yet approximately 0.2 hectares in the Red River Delta (based on GSO 2012 data in Nguyen T. H. 2017). Medium- and large-scale production is still rare, although efforts are being made to cluster the rice plots of 30 to 50 farmers at a time and to jointly operate them as a commercial farm in what is known as the “small farmer, large field” model.21 A large majority of Vietnam’s 640,000 coffee farmers have plantings below 1 hectare, although since the mid-2000s, some consolidation of production has occurred, with 3- to 10-hectare farms accounting for a growing share of output (Havemann et al. 2015). This modest pace of consolidation has possibly had implications for pollution and pollution control. Smallholders may be more prone to overusing inputs (with less capacity and incentive to be more precise in their use of chemicals).22 The fact that there are large numbers of them—and that collective action institutions happen to be weak in Vietnam’s farm sector—also increases the challenge of policing or achieving behavioral change in the sector.

The problem of fertilizer overuse is particularly acute in Mekong Delta rice farming, and in Central Highlands coffee production.23 A majority of both rice and coffee farmers apply fertilizer at rates that largely exceed the levels recommended to maximize either yields or profits. In rice farming, for example, most farmers have been found to apply fertilizers about 20 to 30 percent above the recommended levels (based on 2014 Mekong Delta Development Research Institute [MDI] surveys in Kien Giang and An Giang Provinces 2014 cited in Nguyen T. H. 2017). At around 180 kg of nutrients24 per hectare of harvested paddy during 2010–2011, the application rate in Vietnam was about 30 percent less than it was in Japan, China, or Malaysia (26 to 33 percent), but 50 percent higher than it was in Indonesia, and over 200 percent higher than in it was in the Philippines and Thailand (see Figure 5). In coffee farms, nitrogen application rates have been found to exceed levels recommended by agricultural extension services by 50 percent, and phosphorus by 210 percent.

Many factors contribute to fertilizer’s often wasteful and imbalanced use. Reasons for fertilizer overuse include its ease of use and wide availability at partly subsidized prices—domestically produced fertilizers...

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20 In the Central Highlands, which produces the vast majority of Vietnamese coffee, satellite imagery from 2014 showed that the actual planted area was more than 25 percent larger than what official statistics recorded in 2010. And in Dak Lak province, specifically, 19 percent of the planted area—or 41,500 out of 221,000 hectares—was mapped as land deemed either unsuitable or marginally suitable for coffee (based on data from NIAPP 2014 in Havemann et al. 2015).

21 Actively promoted by Vietnam’s Departments of Agriculture and Rural Development (DARDs), the model supports groups of 25 to 100 neighboring farms that manage their land as though it were a single, medium-scale farm, without farmers giving up their land rights. Farmers break down the low walls between their plots, prepare the land togeth, manage water jointly, and plant the same crop varieties. DARDs have intervened, for example, by encouraging farmers to form groups, facilitating contracts between such groups and rice millers, and financing or providing land-leveling, advisory, and other services.

22 See, for example, evidence from China and Indonesia in Sun et al. 2012; Ju et al. 2016; Zhou et al. 2010; and Osorio et al. 2011.

23 Fertilization practices have been less closely studied in maize systems.

24 Nitrogen, phosphorus, and potassium.
benefit from subsidized energy and preferential tax rates—as well as diminished soil fertility, and the influence of marketers, including extension agents in some cases. Waste also occurs because soil testing remains rare in Vietnam, as does the custom-blending of fertilizers to meet site-specific needs; and available fertilizer is often of poor quality. Fertilizer losses are often made worse by fertilizer’s manual, surface, and poorly timed application (which make it prone to runoff), and overirrigation (notably of coffee). The overuse of fertilizer is also self-perpetuating, as ever more fertilizer is used to palliate the detrimental effects that its overuse has on soils and their fertility. This is similar to how the abuse of pesticides begets ever more reliance on these chemicals to fend off the resurgence of pest populations that have been aggressively but not judiciously managed.

Pesticide overuse is also rampant in certain parts of Vietnam, where farms have quickly gone from minimal pesticide use to relatively high levels (compared to recommended ones), with concerns about overuse pertaining especially to rice, though even higher levels are used in vegetable farming on average (Anh 2002 in Pham et al. 2012). As noted, the use of pesticides has grown dramatically since imports were legalized in 1986 despite over a decade of efforts to moderate this trend. Average pesticide use in Vietnam compares to levels seen in the United States and the EU on a per hectare basis (based on FAO data), but its use is highly concentrated in rice production. In rice systems, the use of pesticides is thought to have largely exceeded what was necessary to achieve observed levels of output growth (Bui, Vo, and Nguyen 2013, and Nguyen et al. 1999 in Nguyen T. H. 2017).

Part of the explanation is that only a minority of pesticide sellers, extension agents, and farmers understand correct pesticide use, and efforts to promote integrated pest management (IPM) have fallen short of expectations. Farmers continue to widely disregard guidelines on dosing, mixing, timing, and method of application. For illustration, one study found that 50 to 60 percent of rice farmers were using pesticides at rates that exceeded recommended levels because they believed that higher doses were more effective (Bui, Vo, and Nguyen 2013 in Nguyen T. H. 2017). Another study found that 38 to 70 percent of farmers in southern provinces were using pesticides at rates exceeding recommended levels, with nearly 30 percent mixing many types of pesticides together at the time of application despite this being a dissuaded practice (Tran Thi Ngoc Lan et al. 2014).

Farmers often also disregard guidelines on the disposal of used pesticide containers, or the handling of application equipment—sometimes for lack of better options. Pesticide containers are routinely dumped, along with their chemical remnants, directly into fields, canals, and streams, as in both the Mekong and Red River Deltas (Pham et al. 2012). One study found more than 70 percent of farmers in the Mekong Delta to be dumping pesticide packaging into canals or rice fields; only around 17 percent of farmers were reported to collect the containers and either bury them

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25 Including in connection to the already noted loss of soil alluvium caused by dykes; and potentially in connection to the use of marginal land, the continuous mining of soil by intensive farming activities, and soil acidification also resulting from them.

26 Its timing in relation to rain or irrigation.

27 Under collective agriculture, the government supplied pesticides at subsidized prices and recommended spraying on a calendar basis, with little or no attention to field conditions (Pincus 1995 and Chung and Dung 2002 in Dasgupta et al. 2007).

28 Also see the results of a 2015 survey by the Research Center for Rural Development and others; http://library.ipamglobal.orgfspui/bitstream/ipamlibrary/818/1/Knowledge-Attitude-and-Practice-KAP.pdf.
or sell them for recycling (Toan 2013). Approximately 90 percent of farmers said they washed their sprayers right away at the rice fields, canals, ponds, or rivers (Toan 2013). It is unclear, meanwhile, that any recycling of pesticide packaging is desirable given the lack of infrastructure to properly collect and recycle what in 2015 was recognized as a form of hazardous waste (implying that recycling it is not even legal).

All these practices not only result in suboptimal pest control leading to more pesticide use (brown hopper outbreaks have been attributed to pesticide abuses, for example), but also increase unnecessary exposure of wildlife and people to pesticides. By some accounts, intensively farmed rice fields have, by some accounts, become dead zones, devoid of the snails, frogs, fish, mice, and other creatures that once inhabited them.29 One study in the Mekong Delta, for example, found certain surface waters so polluted with pesticides that they were not suitable for farming activities (UNU-EHS 2010). Pesticide runoff has been known to adversely affect river-based fisheries, although the extent and economic costs of this are not well-known. Groundwater accessed through wells has also been found to contain pesticide residues exceeding safe drinking water standards (Lamers et al. 2011). This is especially harmful to farmers and rural communities, which suffer disproportionately from pesticide poisonings and potentially related cancers (Dasgupta et al. 2007). However, it also affects consumers more widely because crops are often harvested too soon after pesticide applications, resulting in unsafe levels on produce (Hoai et al. 2011), and a dozen pesticides have been detected at rates that exceed drinking water standards in ground-, surface, well, rain, and bottled water (Nguyen, C. G. D. et al. 2015; Lamers et al. 2011; Toan et al. 2013).

Concerning levels of pesticides have also been found in fish samples (Hoai et al. 2011). The detection of excessive pesticide residues on plant products has also led to trade rejections and disrupted trade flows,30 although the cost of these rejections and their effects on the industry’s reputation and sales have not been fully analyzed.

A concern that is parallel to the excessive and improper use of pesticides in Vietnam is the toxicity of the pesticide mix. A survey of farmers in the Red River Delta, for example, found that nearly one out of three pesticides used by farmers belonged to the category of pesticides that the World Health Organization deems “extremely or highly hazardous” (Category I) (Pham et al. 2012). These included organophosphates, organocholrines, pyrethroids, and carbamates, among others. In addition, several banned or unregistered pesticides (such as methyl parathion, methamidophos, and carbofuran) were found to be in use—though the percentage was declining. In general, it is reported that Vietnamese farmers have a tendency to use older, less expensive, nonpatented pesticides that can be manufactured or blended domestically, and that happen to be more toxic and persistent than others (Pham et al. 2012). An inspection of pesticide traders, vendors, and farmers carried out by MARD in 2010–2011 revealed that around 20 percent farmers were using pesticides in violation of applicable regulations (using illegally imported, banned, and even fake pesticides) (Nguyen T. H. 201731). The continued use of banned pesticides is partly attributable to their relatively low prices (itself aided by price competition32), and at least partly to their efficacy (due to their toxicity to a broad spectrum of pests). In addition, the enforcement and control of hazardous chemical use has generally been weak (Hoi et al. 2016).

The situation of fertilizer and pesticide overuse has the potential to be remedied. Pilot programs and field studies have demonstrated that significant improvements in the use of agrochemicals are possible with the right practices—and can yield farmers significant savings. For example, Vietnamese rice

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29 One study found that pesticides to be harming the growth and survival of climbing perch (a fish) in Mekong Delta rice fields in 2007 (Nguyen T. T. 2016).
30 See, for example, the suspension of Vietnamese rice exports to the United States due to pesticide violations in 2016; http://e.vnexpress.net/news/business/vietnam-suspends-rice-exports-to-us-after-pesticide-violations-3476874.html. Pesticide-related rejections of fruits and vegetable exports have, however, been dwarfed by rejections related to microbiological contamination (UNIDO 2015).
31 Also see reports on smuggled pesticides; http://infonet.vn/80-thuoc-bao-ve-thuc-vat-nhap-tu-trung-quoc-post153761.info.
32 See Truong Quoc Tung 2015.
farmers participating in the “1 Must and 5 Reductions” program in the Mekong Delta were able to reduce their production costs by 18 to 25 percent per hectare of harvested crop without sacrificing yields (Nguyen T. H. et al. 2015). Whether they are related to low awareness and technical capacity, a lack of access to better technology, labor constraints, or other factors, the impediments to scaling up this program merit further investigation. Similarly, Technoserve (2013) estimated that farmers’ incomes could increase by around 30 percent (from a base of US$1,500 per year, at 2013 coffee prices) as a result of lower pumping and fertilizer expenditures, and higher yields. However, these have been insufficient or underestimated by farmers—or perhaps too long term—to inspire change.

Another significant pollution concern is the burning of crop residues such as straw and husks. Studies on this phenomenon have shown burning to be widely practiced, including by rice, coffee, and maize farmers. One found that up to 98 percent of surveyed farmers in the Mekong Delta burned straw after the winter-spring season, 90 percent burned it after the summer-autumn season, and 54 percent burned it after the autumn-winter season (Tran Sy Nam et al. 2014). Burning crop residues has been a common practice to eliminate wastes after harvesting because it is an inexpensive and quick way to prepare land for the next crop. Certain provincial arms of MARD (such as the Dong Thap DARD in An Giang) have reported some decrease in rice straw burning since 2015, which they have attributed to increases in the market price of rice straw and the availability of equipment to collect and process it. The claim that burning has declined remains anecdotal, however, and there is no evidence of sustained and wider change. The challenges that China has encountered in fully controlling burning despite its well-resourced efforts to enforce bans on this practice suggest the need for caution in making this assessment.34

The burning of agricultural residues emits pollutants that pose a significant health hazard and may contribute to short-term climate warming. Emissions include sulfur dioxide (SO$_2$), nitrogen oxides (NO$_x$), carbon monoxide (CO), black carbon (BC), organic carbon (OC), methane (CH$_4$), carbon dioxide (CO$_2$) volatile organic compounds (VOC), nonmethane hydrocarbons (NMHC), ozone (O$_3$), aerosols, and others (Tripathi, Singh, and Sharma 2013).

Separately, agriculture is the second-largest contributor to overall greenhouse gas emissions in Vietnam, and rice production the leading source of agricultural emissions. Rice’s footprint is all the more significant if its fertilizer-related emissions are factored in alongside those generated by the decomposition of organic matter in paddy fields’ standing waters (which emit nitrous oxide and methane, both powerful greenhouse gases) (see Figure 6). Fertilizer use, meanwhile, has been the second-fastest-growing source of agricultural greenhouse gas emissions behind manure management35 (see “agricultural soils” in Figure 7). As with fertilizers and pesticides, farmers stand to privately benefit in many cases from the application of rice farming practices proven to mitigate pollution levels. This calls for reaching a deeper understanding of the incentive structures and other factors that may be holding back their much wider adoption.

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33 Developed by the International Rice Research Institute in collaboration with the An Giang Department of Agriculture and Rural Development, “1 Must Do and 5 Reductions,” or 1M5R, calls for farmers to use certified seeds (the “1 must”), while reducing the use of four production inputs (seed, water, pesticides, and chemical fertilizers) and postharvest losses (the “5 reductions”). This estimate is based on the piloting of the 1M5R package in the Mekong Delta’s Kien Giang and An Giang provinces through 9 cropping seasons during 2012–2014. The study finds that 1M5R could potentially save farmers US$1.4 billion per year, assuming 4 million hectares of double-cropped rice.

34 That said, the rates of residue burning are comparatively low in China, estimated at less than 24 percent in 2013, compared to 54 percent to 98 percent in Vietnam, depending on the season (Lao et al. forthcoming; Tran Sy Nam et al. 2014).

Public sector action to date

There appears to have been a turning point in recent years with respect to government action on agricultural pollution control. As noted, MARD’s 2013 Agricultural Restructuring Plan reflected growing recognition of the agricultural pollution challenge and its ramifications by central and local government authorities. More recently, the legal framework for agricultural pollution prevention and control has been strengthened and much more tailored to the agricultural sector’s specific set of challenges and realities. A turning point in Vietnam’s agro-environmental policy seems to have been reached in 2015 as several laws and implementing measures came into effect or were adopted (see Figure 8). These included the Law on the Promulgation of Legal Documents (effective 2015), which among other things instructs various government bodies to develop legal documents pertaining to different aspects of agro-environmental protection. Measures also included laws on environmental protection (effective 2015), plant protection and phytosanitary matters (effective 2015), and veterinary matters (adopted 2015); as well as a host of implementing measures. The latter included directives and circulars on antibiotics use and toxic substance residues in animal agriculture, and food safety; on the (reorganized) roles and responsibilities of province-level authorities (DARDs); on pesticide product management; good agricultural practices; biogas; and more. Previously, agricultural activities were generally subject to broader environmental and food safety legislation—a less sector-specific set of laws with limited connection to one another. One notable exception in this respect was the Law on Fisheries of 2003, though its implementation proved largely ineffective and is being revised as of 2017. In fact, fisheries regulations have followed a similar pattern, having begun to gain in specificity and enforceability since 2013 (technical standards were issued in 2013, 2014, and 2015, to try to give it more force).

The work of specifying and tailoring laws and regulations is ongoing, and some of it is starting to be accompanied by public investments in supportive infrastructure and capacity. At the time of writing (2017), for example, MARD is in the process of preparing a new circular relating to the management of agricultural chemicals, residues, and wastes, in which it will reportedly be guided by the

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36 For example, MARD’s crop protection agency was tasked with proposing and preparing circulars and directives relating to fertilizers and pesticides, and various entities within and outside of MARD were called upon to provide comments and contribute to this process.

37 These included laws that are still on the books such as the Law on Environmental Protection (2005), the Law on Water Resource Use and Management (2008), the Law of Biodiversity (2008), the Law on Food Safety (2010), the Law on Environmental Fees (2010), and the Land Law (2013).
objectives of reconciling growth and environmental protection and improving coordination, enforceability, and accountability. Since 2016, MARD and MONRE have been collaborating to develop guidance on the handling and management of used pesticide containers, and to “build capacity” (including technical expertise and infrastructure) to eliminate highly toxic and persistent pesticides. In parallel, the Ministry of Finance is financially supporting MARD in backing local authorities in intercepting and destroying banned pesticides and fining violators.

While this ongoing flurry of legal action represents a critical step toward gaining control over farm-level pollution, multiple implementation challenges remain, a selection of which are discussed below.

- Monitoring and controlling nonpoint sources, especially with limited (human/technical and financial) resources that are sometimes spread thin. Agricultural nonpoint source pollutants are difficult to trace and measure, making it difficult to identify and fine (or take corrective action against) polluters. This is especially true with limited financial resources for monitoring and oversight, limited staff, and limited technical expertise. For example, MARD’s Plant Protection Department has about 4,000 staff, and there are on the order of 10 million pesticide-spraying farmers to oversee. This means that each staff must monitor about 2,500 farmers, on average, a task that with current technical resources and essentially no support from local authorities is reportedly impossible (MARD 2016a). For similar reasons, the government’s capacity to control the quality of fertilizer remains limited, leaving it relatively powerless to curtail the commercialization of fake and low-quality fertilizers. Furthermore, limited resources are not always put to best use—and are potentially spread thin—considering that there may be overlap in the roles and responsibilities of different parts of the administration, and that

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**Figure 8. Key legal measures pertaining to agro-environmental policy since 2004**

<table>
<thead>
<tr>
<th>Year measures came into effect</th>
<th>Laws</th>
<th>Implementing measures</th>
<th>Technical regulations and standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td></td>
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<td>2005</td>
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<td>2016</td>
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<td></td>
</tr>
<tr>
<td>2017</td>
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</tbody>
</table>

Note: See details on legal measures in a separate annex available online. The figure shows major legal provisions related to environmental protection that are in effect, focusing on those relevant to farm-level agricultural pollution. Years shown on timeline are when measures came into effect. DARD = Departments of Agriculture and Rural Development. MARD = Ministry of Agriculture and Rural Development.
there is often no coordination among different government bodies.

- **Unclear responsibilities and lack of coordination.** A lack of clarity and coordination of roles and responsibilities has generally contributed to weak enforcement of laws and regulations—perhaps because overlap in responsibilities gives rise to confusion and in turn excuses not to comply; or because some aspects of the law slip through the cracks without any agency taking responsibility. Until recently, for example, synthetic fertilizers were under the purview of the Ministry of Industry and Trade, and natural fertilizers were under the purview of MARD, leaving no one to oversee producers of both kinds of fertilizer. Agro-environmental roles and responsibilities are assigned to a range of departments within both MONRE and MARD, yet coordination among them is lacking, as is clarity on where differences in these roles and responsibilities lie (that is, how they relate to each other). For example, within MARD alone, the Department of Crop Production, Department of Livestock Production, and Department of Animal Health each have their own environmental management division; while multiple functional departments within the Directorate of Fisheries—which does not have a dedicated environmental department—also have environmental management responsibilities.

Again, the key issue is lack of coordination. Until recently, roles and responsibilities have been similarly disjointed or overlapping at the province and local levels, a situation recognized as leading to ineffective oversight of agrochemicals and agricultural residues and wastes, and resulting in troublesome environmental outcomes. To illustrate the consequences, no legal cases have been brought or penalties imposed in connection with the pollution of various rivers such as the Song Cau, Nhue, Đày, and Dong Nai, even though they have been contaminated to the point of being unfit for domestic uses, and in some cases even agricultural uses (such as irrigation and aquaculture). Another illustrative consequence is that, barring consumer fatalities (if these can even be retraced to their source), farmers face no legal consequences in connection with the use of highly toxic and banned agrochemicals, or the potentially hazardous overuse (or misuse) of agrochemicals, more generally.

- **That said, the government seems to be taking proactive steps to improve resource use and coordination, and to strengthen its monitoring and enforcement capacity**—in part by making better use of human/technical and financial resources. In 2015, for example, guidelines were issued by MARD and the Ministry of Home Affairs (MHA) to clarify and streamline the agro-environmental roles and responsibilities of different administrative entities of DARDs in order to remedy the high level of fragmentation of agricultural pollution control efforts at the provincial level. MARD then merged and reorganized several administrative departments at the province level, putting just one department in charge of crops, livestock, and aquaculture pollution oversight, respectively. In 2016, MARD also took steps to mobilize local resources (human, financial, and material) and develop plans to strengthen agro-environmental monitoring, with a focus on intensively farmed parts of the country such as the Mekong Delta. Priorities that have been set include reducing agrochemical use; increasing the treatment and recycling of agricultural residues and wastes; increasing the adoption of “advanced” cultivation and crop management techniques; eliminating the use of certain toxic plant protection substances (that is, pesticides), including by controlling the importation and sale

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38 Their BOD5, COD, and TSS levels are several times the standards specified for “domestic water supply with appropriate treatment,” and some parts are above agricultural use standards (A1 and B1 standards specified in QCVN 08:2008), with sources of pollution including domestic and industrial sources. Agricultural sources are likely larger contributors to the contamination of the Tien and Hau Rivers, among others, in the Mekong Delta (Bao Anh 2016 [http://thanhtra.com.vn/xa-hoi/moi-truong/ nguon-nuoc-song-ngay-cang-o-nhiem-nghiem-rong_r14c11435n101615]).

39 The measures in question were MHA/MARD Joint-circular No 14/2015/TTLB-BNNPTNT-BNV and MARD Circular No. 15/2015 / TT-BNNPTNT, with the latter providing more specific details on what was to change.
of illegal and expired pesticides; and providing guidance on the collection and treatment of used packages of agrochemicals and veterinary drugs. The previously mentioned circular that MARD is preparing also aims to improve coordination as relates to agro-environmental policy.

- **A lack of specificity or overlap in regulatory provisions has sometimes hampered enforcement.** In some cases, authorities have found it challenging to demonstrate that violations have taken place, either for technical reasons, or due to a lack of legal clarity when different guiding circulars are in place. In other cases, environmentally damaging practices—for example, the use of electricity in fisheries—have been a few steps ahead of regulatory provisions and not explicitly described or connected to a clear course of corrective action. In some instances (even where farm capacity is not at issue), authorities’ ability to hold farms accountable has been complicated by duplicative regulations, leading to genuine confusion or perhaps undermining the basis for their enforcement. Overlap in aquaculture wastewater management standards issued by MARD and MONRE has reportedly detracted from their adoption and enforcement in the aquaculture industry. In some cases, it is the suitability of regulatory provisions that is at stake, as when these are out of step with farms’ capacity—either to understand or to comply with them. Certain standards that are meant to govern livestock production (specifically wastewater management), for instance, are out of step with the realities of the large parts of the industry.

- **Difficulty and reluctance of authorities to enforce environmental laws and regulations especially vis-à-vis small farmers, and inability of farms to comply.** Although, aggregatedly, small farmers contribute significantly to agro-environmental pollution, their activities are, as noted, difficult if not impossible to oversee. Moreover, they are often seen as vulnerable—including to the effects of nonfarm pollution— and lacking in capacity. And indeed, they sometimes do lack the requisite financial capacity, physical space, or skills and expertise to adopt certain technologies or practices and meet certain standards.

- **Economic incentives and disincentives lack the power to persuade or dissuade farmers.** Penalties for noncompliance with laws and regulations—even when they are imposed (see the problem of “unenforceability” under the challenges of monitoring small farms and nonpoint sources, above)—are generally inadequate (MARD 2016b). Meanwhile, the focus of government seems to have remained largely on policing and punishing bad practices (for example, inspecting imported fertilizers at borders, requiring the registration of agrochemicals being imported, sold, or produced domestically, punishing the production of fake fertilizer, and threatening violators with weak fines), rather than intervening preventively and using a broader array of economic incentives, including both “carrots” and “sticks,” to induce behavior change.

- **More structurally oriented measures aimed at preventing pollution or its worst impacts have remained the exception, and have seen limited results to date.** In particular, MARD’s policy under the Livestock Subsector Restructuring Program to redistribute “large-scale” commercial livestock production in space—and specifically to move these operations away from dense population centers and to less populated, “biosafety production areas” that are far from residential areas—is an example of a measure meant to shape the industry’s geographic layout and density. However, from this perspective, the industry has remained nearly stagnant. The livestock subsector’s continued dominance by

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40 Most recently in connection to several mass fish kills that have resulted from repeated and severe instances of industrial pollution of the Am River in Thanh Hoa and other provinces.

41 One of its targets, for instance, is to decrease the Red River Delta region’s share of national pig production from 26 percent to 15 percent by 2020, and the Mekong Delta regions’ share from nearly 11 percent to 5 percent.
small farms (not explicitly targeted by the policy) has also not helped in this respect.

In parallel to implementation challenges, it is possible that certain government policies have unintentionally and indirectly fueled polluting agricultural practices or activities. Possible examples of double-edged government intervention may include implicit fertilizer subsidies (through policies favorable to state-owned fertilizer companies), and investments in the construction of “protective” dykes (to mitigate flooding and enable more rice harvests per year, to the extent that they can have repercussions for soil fertility). Any fast-tracking of livestock farms or their licensing with little regard for environmental management plans and facilities would be another example of one policy objective (such as supporting livestock production capacity) being pursued at the expense of several others (human and environmental health).42

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42 To illustrate a form of noncompliance that is often overlooked, concentrated livestock farms, such as those with over 100 pigs, are legally required to have a suitable waste treatment system, such as a biogas digester. Farms that size, however, lack a use or market outlet for the “large” quantity of energy such biodigesters generate, and have little incentive to invest in one, or to use it as designed. As a result, many farms either lack adequate waste management facilities, or release biogas and associated effluents directly into the environment, causing water and air or climate pollution.
WAYS FORWARD

Going forward, Vietnam can make important strides when it comes to fully incorporating sustainability considerations into the country’s agricultural intensification policies, strategies, and programs, and implementing them more effectively. This is not only a public health and ecological necessity (China’s situation warns of the potentially high costs of ineffective policy). Achieving higher product quality, food safety, and environmental performance will also be essential to sustain high levels of agricultural output and value addition, and to help Vietnam’s agricultural exports grow in relevance in the most demanding markets. The potential for gain has already been recognized in efforts to increase sales of higher-quality, branded rice, and to meet sustainable sourcing criteria sought by certain international companies, for example.

Significant potential for improvement lies in the better application of Vietnam’s existing legal and regulatory framework for pollution control. For this, the state will need to intervene in ways that offer farmers better technical options, and also modify their incentives to encourage adoption and/or compliance.

National good agricultural practices (GAPs) have already been developed in several domains and are ripe for scale-up. Further studies are needed to more deeply understand what constrains the adoption of these practices and to effectively direct resources to that end. At the same time, additional research and innovation efforts are needed across a range of domains to support the development or adaptation of new GAPs. Programs promoting and supporting their adoption need to be developed with full consideration for value chain realities and dynamics, and farmers’ economic incentives. Program-related messaging may also need adjustment. Often, farmers adopting GAPs do not receive higher prices for their produce, or only a very small premium. The main benefits for farmers typically lie elsewhere, in the forms of reduced input expenses and lower exposure of the farm households and their communities to chemicals and antibiotics.

The state can develop more effective monitoring and enforcement programs to address agricultural pollution issues, especially on intensified commercial farms. These will be facilitated through greater cooperation among agencies including MARD/DARD, MONRE/DONRE, and food safety and health departments. Information disclosure schemes on the quality and environmental footprints of agricultural production also need to be developed to avoid unfounded public fear.
and to foster market demand for products deriving from sustainable agricultural practices.

Priorities going forward include:

1. **Enhancing awareness of agricultural pollution among the country’s policy makers, consumers, affected communities, and producers** by using a variety of methods, including school curriculums, awareness days, site visits, event convening, crowd sourcing of solutions, and public dissemination of monitoring results.

2. **Systematically considering the pollution and related implications of all public policies, incentive schemes, investments, and programs—across sectors—with influence over farming practices**, compliance with farming-related regulations and standards, and farming sector structure.

3. **Incorporating agricultural pollution assessments and mitigation plans** into all future agricultural program budgeting and agricultural projects.

4. **Strengthening national and subnational capacity to systematically monitor agricultural pollution**, perhaps initially focusing on some key commodities or known agricultural pollution “hotspots.”

5. **Developing, in relation to agricultural pollution “hotspots,” action plans** with time-bound steps and outcome goals. Plans can be developed at different geographic scales, involving different levels of government, and with the participation of affected producer and community groups. These can address such things as legal measures and their enforcement as well as farmer incentives and motivations, and structural drivers of pollution.

6. **Reviewing existing regulations and standards** of relevance to agricultural pollution prevention and control, and benchmarking them internationally, to identify potential gaps and assess suitability in the context of national agricultural sector realities. This can also be done with respect to approaches used to implement and enforce legal measures.

7. **Strengthening the enforcement of existing environmental laws and regulations**, including through investments in human capital and equipment, and the capacity and resources of entities (public or community-based) with a role in oversight.

8. **Developing and disseminating technical guidance on context-relevant good agricultural practices**, including ones relating to input and “waste” management, for farmers and service providers, and **scaling up proven good agricultural practices** using lessons learned from successful (and less successful) projects and programs (such as VietGAP, 3G3R [3 gains 3 reductions], 1M5R, and private international standards). This can be done, among other ways, by developing programs that harness or magnify economic incentives for farmers (or farm service providers) to adopt better practices.

9. **Funding more learning and research**—including social science research—on pollution’s drivers and impacts, and on **effective responses** to major pollution problems, to support more evidence-based prioritization of public resources and the design and implementation of responses.

10. **Establishing formal processes to periodically evaluate policy and program effectiveness**, building on emerging evidence generated by ongoing monitoring and pollution research, and to propose changes to policies and programs on the basis of findings.


References


